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Suspect Restraint and Sudden Death

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When hog-tied restraint is used to control violent suspects, officers can take precautions to prevent sudden deaths.

One law enforcement technique for controlling violent suspects is to place them in a hog-tied and prone position by binding their hands and feet together behind their back and placing them on their stomach. This physically incapacitating position, however, makes it difficult for subjects to breathe and can cause them to die.(1)

Because of the risks associated with hog-tied and prone restraint, officers must monitor subjects closely for signs of respiratory distress. This article describes how hog-tied restraint can cause death, what other factors might contribute to such a death, some steps that can be taken to prevent sudden deaths, and what evidence law enforcement officers can provide to assist medical examiners during death investigations.

Positional Asphyxia

When a hog-tied subject dies, forensic pathologists generally attribute the death in whole or in part to positional asphyxia resulting from respiratory compromise. Positional asphyxia occurs when the position of the body interferes with the person's ability to breathe. Breathing involves interaction of the chest wall, the diaphragm, and the muscles of the rib cage and abdomen. Interference with proper breathing produces an oxygen deficiency (known as hypoxia) in the blood,(2) which disturbs the body's chemistry and creates the conditions for a fatal rhythm disturbance in the heart.

Contributing Factors

An examination of reported positional asphyxia-related deaths revealed that several other readily observable factors can increase a subject's susceptibility to sudden death when officers place the subject in the hog-tied and prone position. These include obesity and psychosis, which covers both organic (i.e., paranoia, schizophrenia, etc.) and drug- or alcohol-induced psychotic behavior.

A large, bulbous abdomen (a beer belly) presents significant risks because it forces the contents of the abdomen upward within the abdominal cavity when the body is in a prone position. This puts pressure on the diaphragm, a critical muscle responsible for respiration, and restricts its movement. If the diaphragm cannot move properly, the person cannot breathe.



The second significant contributing factor is psychosis, often induced by drugs or alcohol. Drugs, such as methamphetamine, cocaine,(3) and LSD, create a state of delirium frequently accompanied by violent muscular activity. The mind-altering character of these drugs, combined with the added outbursts of violent and vigorous muscular activity, can cause individuals to lose their breath more quickly than expected. When the hog-tied position prevents recovery from such an oxygen deficit, cardiac rhythm disturbances can occur, resulting in death.(4)

Other pre-existing physical conditions also can contribute to sudden in-custody death. Any condition that impairs breathing under normal conditions will put a subject at a higher risk of respiratory failure when a situation escalates to the point that hog-tied restraint must be employed. Heart disease, asthma, emphysema, bronchitis, and chronic pulmonary disease fall into this category. Clearly, officers subduing a violent subject will not be able to pause in the midst of the action to inquire about the subject's medical history. It might be prudent, however, for correctional officials to be aware of inmates' medical records and be alert for potential problems when using hog-tied restraint.

Prevention

Criminal justice professionals across the country have sought methods to ensure the safety of subjects restrained in the hog-tied and prone position. The simple fact of the matter is that even if officers take precautions, hog-tied and prone restraint is inherently risky. Therefore, instructors should stress awareness and vigilance when teaching officers the proper use of hog-tied restraint.

First, officers must be made aware of the inherent risks of using hog-tied restraint. They should learn how the adverse position affects a subject's breathing and how to recognize signs of respiratory distress. They also must be able to recognize the factors that contribute to positional asphyxia.

Whenever hog-tied restraint is employed, officers should determine whether subjects have used drugs or suffer from cardiac or respiratory diseases. Hog-tied subjects should not be left on their stomachs; rather, they should be rolled onto their side. During transport, officers should ensure that hog-tied subjects do not fall face-down in the back of the squad car.

Instructors must stress vigilance in monitoring the subject's condition. The process of hypoxia is insidious, and subjects might not exhibit any clear symptoms before they simply stop breathing. Generally, it takes several minutes for significant hypoxia to occur, but it can happen more quickly if the subject has been violently active and is already out of breath. If the subject experiences extreme difficulty breathing or stops breathing altogether, officers must take steps to resuscitate the subject and obtain medical care immediately.

At present, no satisfactory alternatives to hog-tied and prone restraint exist. Police administrators who wish to prevent deaths that occur during hog-tied restraint should not authorize use of the maneuver. Yet, experience shows that sometimes no other type of restraint will control a violent, aggressive subject. Until an alternative method of restraint is developed, officers must be aware of the risks, vigilantly monitor subjects' conditions, and take every precaution to avert fatalities.

Death Investigations

When a subject dies while in the hog-tied restraint position, the autopsy sometimes reveals the presence of significant natural disease, such as heart disease. For the examining pathologist, this creates a dilemma. Should the death be attributed solely to the natural disease? Was the disease

aggravated by the adverse position of the body? Or did the positional restraint alone cause the subject to die?

Unfortunately, current postmortem technology alone cannot make such a determination. Hence, the examining pathologist must make a judgment call. The pathologist needs three things to make an assessment - an autopsy, a toxicological analysis of body fluids, and a detailed history of the events surrounding the subject's death.(5)

First, a careful and complete autopsy can reveal whether a catastrophic natural disease, such as a heart attack or stroke, caused the death. Similarly, toxicological analysis of body fluids for the presence of drugs and alcohol can provide important information. Yet, such medical information cannot provide the complete picture needed to determine the cause of death.

Police agencies can help by providing a detailed description of events that led to and occurred during the restraint maneuver. Such a report should contain explicit witness statements about the subject's behavior - especially noting any unusual physical respiratory signs, such as vocalizing, gurgling, gasping, and difficulty breathing - as well as comprehensive circumstantial information about the arrest, take-down, and restraint. The medical examiner can use this information to make a careful, thoughtful analysis of the events in the context of the autopsy and toxicological findings.

Conclusion

Determining the cause of death of subjects who had been placed in the hog-tied and prone position is one of the most difficult tasks in all of forensic medicine. Many factors can convene to cause respiratory failure when officers use this restraint maneuver. If death occurs, law enforcement agencies must provide medical examiners with a clear and complete description of preceding events, so that doctors can determine the cause of death accurately.

Awareness of the potential for subjects to die in the hog-tied and prone position is the first step toward stopping it from happening. Training in the use of hog-tied restraint, monitoring subjects, and recognizing the signs of respiratory distress can help officers prevent sudden deaths.

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3. Recent pharmacological research has demonstrated that physical restraint sensitizes laboratory animals to the effects of cocaine. These findings indicate that stress can augment some of cocaine's effects and that any type of restraint, including but not limited to the prone and hog-tied position, during cocaine agitation can result in sudden death. See R.L. O'Halloran and L.V. Lewman, "Restraint Asphyxiation in Excited Delirium," *American Journal of Forensic Medical Pathology* 14, 1993, 289-295.
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SIDEBAR

Caring for Subdued Subjects

To minimize the potential for in-custody injury or death, officers should:

1. Get hog-tied subjects off their stomachs
2. Determine whether subjects have used drugs or suffer from cardiac or respiratory diseases
3. Monitor subjects carefully for breathing difficulties/loss of consciousness
4. Be prepared to administer CPR
5. Obtain medical assistance immediately
6. Inform detention facility custodians of pre-existing medical conditions or respiratory difficulty.

Adapted from "Positional Asphyxia - Sudden Death," Bulletin of the National Law Enforcement Technology Center, National Institute of Justice, June 1995.

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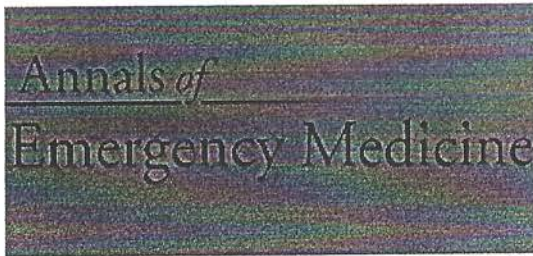
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Positional Asphyxia

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To the Editor:

The recent article by Chan et al¹ concerning restraint position and positional asphyxia reports a well-done study providing further valuable insight into the complex issue of sudden death during police custody. We were involved in a similar study a decade ago and have reviewed this more recent work with great interest.² However, we are concerned with one aspect of the interpretation of the results.

The authors measured significant differences in pulmonary function test results between control and restrained individuals, but describe the changes as "not clinically relevant." Based on their findings, the authors suggest that factors other than body positioning are more important determinants for the sudden deaths that occur while in the restraint position. We agree that many factors should be considered in evaluating a case of sudden death, but urge caution in the application of clinical parameters to the situations of death in police custody that prompted these studies.

As physicians, our training and experience have provided insight into matters of clinical relevance. As forensic pathologists, our training and experience have routinely provided insight into the spectrum of illness, injury, and death that occurs, often quite literally, in the "street" and is not well known to clinicians. The clinician's involvement in such cases, if any, is at the end of an unsuccessful resuscitation attempt. Applying only "clinically relevant" values to a measurement may lead to misinterpretation of findings in deaths that occur outside the clinical setting. For example, blood morphine levels founds in individuals who have died after intravenous injection of heroin might well be considered "low" based on the range of morphine levels commonly seen in hospitalized patients receiving pain medication, yet these individuals are quite dead from the drug. Restrictive pulmonary function alteration that may not be "clinically relevant" might well be one of several contributing factors in some deaths where restraint is used.

In the past decade, we have had the opportunity to investigate or review numerous cases of death during law enforcement custody, involving various forms of physical restraint. The processes leading to death in these cases

developed well separate from any clinical setting. Forensic pathologists see cases of death that are caused by drug intoxication alone and others where death is caused by positional or restraint asphyxia alone. Our experience in reviewing deaths in police custody leads us to believe that multiple factors, rather than one single cause, play a role in deaths where restraint has been applied. The exact pathophysiologic mechanisms of death have not been fully defined. Significant hypoxia from restraint may or may not occur, but a contribution from the restraint position itself to death should not be dismissed.

There are now two controlled studies showing the restraint position to have a measurable physiologic effect. An animal model for the physiologic effect of restraint exists, which was mentioned briefly by the authors.³ The model was used to demonstrate that the combination of cocaine and "restraint stress" produced an increased mortality in rats compared with cocaine exposure alone. The case reviews, the controlled studies, and the animal model point to physical restraint as being one significant factor in this type of death.

It is encouraging that further research is being done in this area, and we hope that additional studies will be conducted.

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Restraint Asphyxiation in Excited Delirium

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Eleven cases of sudden death of men restrained in a prone position by police officers are reported. Nine of the men were hogtied, one was tied to a hospital gurney, and one was manually held prone. All subjects were in an excited delirious state when restrained. Three were psychotic, whereas the others were acutely delirious from drugs (six from cocaine, one from methamphetamine, and one from LSD). Two were shocked with stun guns shortly before death. The literature is reviewed and mechanisms of death are discussed.

Key Words: Positional asphyxiation—Restraint asphyxiation—Excited delirium—Cocaine—Police custody death—Hogtie death—Hobbled (restrained)—Stun gun—Methamphetamine—LSD.

The "hogtied" prone position is commonly used by police to restrain violent persons to protect other people, property, and the subjects themselves during transport to hospital or jail. *Hogtying* means binding a person's wrists and ankles together behind his or her back while he or she lies prone. This may be accomplished by combinations of handcuffs, cords, or specially designed hobbles. Concerns have recently been expressed about the safety of such prone restraint with positional asphyxiation postulated as the mechanism of death in three reported cases (1).

Six similar deaths have been identified in Ventura County, California, during the past 6 years, two in adjacent counties, and three in Portland, Oregon. All cases involved law enforcement officers and two also involved medical personnel. Because of their excited delirious condition, all of the victims were restrained to facilitate transport for medical care or incarceration. To date, seven of the 11 cases have ended in wrongful death lawsuits against the various public agencies involved. These cases are reported here to alert law enforcement agencies, death investigators, and medical personnel that the hogtied prone position in delirious people can have sudden, unexpected, lethal consequences, and requires close monitoring or alternative restraint methods to prevent sudden death.

CASE REPORTS

Case 1

Police were called to an apartment complex because a 29-year-old man was disturbing the peace and damaging property. When police arrived, they found six people attempting to control the suspect. After a brief scuffle, police managed to handcuff him and tie his ankles and wrists behind his back in a hogtie fashion. He continued to struggle and was placed prone, still hogtied, in the back seat of the police car for transport to jail. He continued to scream and struggle for ~5 min. When he suddenly

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stopped struggling, officers noted that he was not breathing. They stopped the car, started cardiopulmonary resuscitation, and called for an ambulance. Resuscitation by paramedics was unsuccessful and he was pronounced dead ½ h later in the emergency room.

Autopsy findings included numerous superficial contusions and abrasions and fresh needle injection sites on a foot. Two parasternal rib fractures were the only internal injuries. Slight coronary artery atherosclerosis was present without microscopic evidence of ischemia, contraction-band necrosis, or inflammation.

Postmortem toxicologic analysis revealed a blood ethanol concentration of 0.08 g/dl and a blood cocaine concentration of 0.6 mg/L.

Case 2

Police were dispatched to a residence when relatives reported that a 44-year-old man, who was high on cocaine and had a knife, was destroying the house. Officers found the suspect screaming and throwing furniture. The suspect broke a window with his fist and grabbed at an officer. With the help of relatives, he was eventually handcuffed. Officers canceled a call for an ambulance and transported him to the hospital in the back seat of the patrol car. When he began kicking at the car windows, he was further restrained in a hogtied, prone position on the car seat. He was talking incoherently and struggling for the first 8 min, but suddenly quieted within two blocks of the hospital. At the emergency room, he was not breathing and was asystolic. Resuscitation attempts lasting 20 min failed.

Autopsy findings were minor abrasions and contusions on the arms, legs, and head, and a large contusion on the back. Old needle track scars and fresh needle punctures were in tattoos on the arms. There were no internal injuries. The heart was slightly hypertrophied, but microscopically normal.

Postmortem toxicologic analysis revealed a blood cocaine concentration of 0.34 mg/L.

Case 3

Police were dispatched to a freeway where a 41-year-old man was running in the traffic lanes, shouting, and waving his arms in an excited manner. The subject kept shouting "Don't let them get me!" Officers and civilians eventually had to remove him physically from the traffic. Because he was combative and irrational, he was placed prone on the ground with wrists and ankles restrained behind his back. He broke the first ankle restraint. A second ankle restraint was being applied while an officer had a knee on the subject's back when the subject suddenly became quiet and stopped breathing. He was in the hogtied, prone position for ~4

min. Paramedics transported him to the hospital where an axillary temperature of 100.3°F was obtained. He was pronounced dead within 30 min.

A friend indicated that the subject had smoked cocaine or methamphetamine several hours before the incident and had become paranoid and excited, hallucinating that police were chasing him. He had had a history of drug abuse.

Autopsy findings were multiple minor skin abrasions, contusions, and lacerations, and a large patterned abrasion on the back. Petechiae involved the conjunctivae and pleura. Slight coronary artery atherosclerosis was present.

Postmortem toxicologic analysis revealed a blood methamphetamine concentration of 0.95 mg/L.

Case 4

Police were called to a residence because a 36-year-old man was physically threatening the owner and destroying property. Officers were confronted by an uncooperative, delirious, violent person who appeared to be on drugs. He was forced to the floor and restrained with wrists and ankles secured behind his back in a hogtie fashion. A pulse of 160 beats/min was noted by one officer. The suspect was carried outside to the front walkway where he was placed prone while officers searched the residence and called an ambulance. When paramedics arrived, the subject was without vital signs. Resuscitation attempts at the scene and at the emergency room were unsuccessful and he was pronounced dead 30 min later. He had not been closely observed during the 20 min that he was hogtied on the walkway and it was unclear when he actually stopped struggling. The subject had a history of prior cocaine and heroin use.

Autopsy findings were numerous superficial contusions and abrasions, many of which were probably self-inflicted, and fresh needle injection sites on the left arm.

Postmortem toxicologic analysis revealed the following blood drug levels: cocaine, 0.28 mg/L; benzoylecgonine, 3.2 mg/L; and morphine, 0.06 mg/L.

Case 5

Police were called to a residence where a man had barricaded himself and minor children inside. Officers broke in to find the subject standing on a bed and waving a beer bottle. He was violent and screaming irrationally about people trying to kill him. Officers handcuffed him and brought him, struggling and screaming, to the police station.

In the police station parking lot, the subject was placed prone on the ground in an attempt to shackle

his ankles. He grabbed an officer and several baton blows and stun-gun shocks were used to loosen the grip. He was carried into the police station where he was placed prone on the floor, still screaming and thrashing. Officers used the stun gun again while placing a leather restraint belt on him, attaching his wrists to it and shackling his ankles. Police reports do not indicate how much weight was placed on the subject's back or whether the ankles were raised behind the back. Officers noticed the subject's respiratory distress and called for medical aid, but resuscitation attempts failed and he was pronounced dead ½ h later. Police reports indicate that several minutes of struggling intervened between the last stun-gun shock and the subject's respiratory arrest.

Autopsy findings were minor cutaneous abrasions and bruises, several paired, punctate, erythematous lesions on the skin of the back from the stun-gun prongs, and focal myocardial contraction-band necrosis.

Postmortem toxicologic analysis revealed a blood ethanol concentration of 0.13 g/dl and a blood cocaine concentration of 0.915 mg/L.

Case 6

Police were called to a hospital room where staff were attempting to control a violent, schizophrenic, 24-year-old male patient who was being evaluated for atrial flutter. Officers used a nightstick and stun gun in controlling the subject. The patient was eventually strapped, prone, to a hospital bed and was transported across a parking lot to a mental health facility. During transport, police used a Taser's antennae on him several times for unclear reasons. The Taser was used several more times in the mental health facility while removing restraints and placing handcuffs behind the patient's back. He was then carried into the isolation room and placed prone with wrists and ankles secured to the bed. Within a minute he had ceased struggling and within several minutes he had ceased breathing. Resuscitation attempts failed.

The patient had had a long history of schizophrenia. One month prior to death, he had been hospitalized for malignant neuroleptic syndrome.

Autopsy revealed moderate coronary atherosclerosis without evidence of ischemia. The only external lesions were minor abrasions of the wrists and ankles. No electrical burns were seen.

Postmortem toxicologic analysis demonstrated blood concentrations of amobarbital of 1.9 mg/L and lorazepam of 0.15 mg/L, both consistent with therapeutic levels of drugs given in hospital.

Case 7

Police were called to a home where a 14-year-old boy, who was reportedly on a bad LSD trip,

had jumped through a window and cut his leg. He was screaming obscenities, talking incoherently, and spitting. It took four adults to restrain him and transport him to the hospital emergency room. Because of his constant struggling, attempts to suture his lacerations were halted and, prone on a hospital gurney, with his hands cuffed behind his back, he was transported three blocks to a juvenile detention center. Still struggling and spitting, he was placed in soft restraints and hogtied. The subject's father reported that manual pressure was applied to his back and shortly thereafter he went limp. He was carried to a padded room, placed prone on the floor, and within a minute was discovered to be unconscious and not breathing. He was rushed back to the hospital where he died after 7 days in a coma.

Autopsy findings were negative for injuries or other abnormalities.

Toxicological tests of admitting blood samples from the hospital were positive for LSD only.

Case 8

Police were summoned by a neighbor who reported a 28-year-old man with a gun who was acting bizarrely and hiding behind bushes, but police didn't make contact with the subject. Seven hours later, he was nude at work, bathing in a sink, and the police were called again. The nude subject fled and entered a small store where he attempted to hide under shelves. He was yelling, kicking, spitting, and biting as he was restrained and handcuffed, prone and hogtied on the floor. One officer was kneeling on his back and others were restraining his arms and legs for ~4 min, when he suddenly lost consciousness. Paramedics transported him to the hospital where he was pronounced dead minutes later.

Neighbors stated that the subject had snorted and smoked cocaine and had been acting strangely for 3 months. The only autopsy findings were abrasions and contusions of the arms, legs, and trunk.

Postmortem toxicologic analysis revealed a cocaine concentration of 0.70 mg/L in blood and amphetamine in urine.

Case 9

A 37-year-old manic-depressive man was in a manic phase when he took his family hostage. Police were called and after a struggle he was restrained prone with ankles and wrists tied behind his back. At some point during restraint, he lost consciousness and stopped breathing. Cardiopulmonary resuscitation was unsuccessful and he was pronounced dead at the hospital.

Autopsy findings were abrasions and contusions along with a bicuspid aortic valve.

A therapeutic level of valproic acid (24 mg/L) was in his postmortem blood.

Case 10

Police were called because a 37-year-old "wild man" with a history of chronic schizophrenia was trying to rip off the top of a car to free someone inside, although the car was unoccupied. The man asked police to cuff him because he was "crazy." He was placed in the back seat of the patrol car, but attempted to kick out the windows and was removed from the car. He was placed prone on the ground and hogtied with handcuffs and leg restraints. Following brief seizures, he stopped breathing. Resuscitation attempts failed and he died within an hour at hospital.

He had had a history of chronic schizophrenia.

Autopsy findings were ligature marks on the wrists and ankles, small abrasions and contusions of the face, and mild cardiomegaly.

A toxic level of amantadine (Symmetrel) was found in the victim's blood.

Case 11

Police were called because a 33-year-old man was acting irrationally and trying to kick down a door. Friends said the subject thought someone was going to shoot him. He ran when police approached, but was eventually caught. Batons were used and he was eventually restrained in a prone, hogtied position on the ground. An estimated 2 min after being restrained, officers heard him say "I can't breathe" and, 1-2 min later, he lost consciousness, stopped breathing, and was transported to a hospital, where he was pronounced dead. He was noted to have been sweating profusely, but no temperature was taken.

Autopsy findings were external injuries consistent with a struggle and baton blows, but no internal injuries.

Postmortem toxicologic analysis revealed a blood cocaine concentration of 2.4 mg/L, a blood benzoylcegonine concentration of 4.3 mg/L, and a blood ethanol concentration of 0.04 g/dl.

LITERATURE REVIEW

These cases exemplify a syndrome that we will refer to as positional asphyxiation during restraint in excited delirium, or restraint asphyxiation.

These cases are remarkably similar. All were young men who exhibited the acute onset of irrational, aggressive, violent behavior with paranoid features, referred to as excited delirium (2,3). The

behavior was so frightening that in all cases the police were called.

Excited delirium, or delirious mania, is a rare form of severe mania, sometimes part of the spectrum of manic-depressive psychosis and chronic schizophrenia. It is characterized by constant, purposeless, often violent activity coupled with incoherent or meaningless speech and hallucinations with paranoid delusions. Such people can be dangerous and may die of acute exhaustive mania (4). Hyperthermia is often part of this syndrome. Cases 6, 9, and 10 involved chronic psychotics, but their temperatures were not recorded.

The rest of the cases are examples of drug-associated acute excited delirium, mostly cocaine induced. In 1981, Fishbain and Wetli reported a case of fatal cocaine intoxication with delirium in a body packer (5). In 1985, Wetli and Fishbain reported the deaths of seven recreational cocaine users who developed acute excited delirium (3). Five involved police custody and three were hogtied in a prone position. One death occurred while the victim was prone with the wrists cuffed behind the back. Ankle positioning in this case was not mentioned. One was handcuffed in a police car when he stopped breathing. His position was not noted. One was restrained in an emergency room. Position was not noted. One died from abdominal injuries sustained prior to being hogtied. All but one of the deceased were men. Blood cocaine levels ranged from 0.4 to 0.92 mg/L. Four had documented hyperthermia. The authors attributed the deaths to cocaine intoxication of an atypical type and speculated that the mechanism of death might involve autonomic reflexes, toxic cardiac dysrhythmia, or "restraint stress," as has been postulated with acute exhaustive mania. The potential adverse effect of hypoxia due to prone restraint was not mentioned.

In 1987, Wetli described perplexing deaths associated with cocaine intoxication following an acute psychotic reaction termed "excited delirium" (2). He described paranoia, disrobing, hyperthermia, and aggression toward glass as common components, along with unusual strength. Typically, subjects continued to struggle after being restrained, and they died suddenly, frequently in the back of police cars.

In 1988, Reay et al. reported that the prone, hogtied position prolonged the recovery time of heart rate and peripheral blood oxygen saturation in 10 normal adults after moderate exercise (6). In his 1992 report, Reay described three deaths occurring during police transport (1). Two of the people were hogtied while prone on the back seats of police cars. One was prone with wrists cuffed behind his back and ankles bound with knees flexed, but was

not hogtied. Two of the three slid forward on the back seat such that one was on the floor of the car between the back and front seats and one was partially wedged between the back seat and the front seat backrest. One was heard to say "Gimme some air." All were taken into custody for violent, agitated behavior. Two had major psychiatric illnesses that explained the behavior, and one was under the influence of alcohol, LSD, and THC (tetrahydrocannabinol). Body temperatures were not reported. All three deaths were attributed to positional asphyxia. The authors discussed physiologic mechanisms of death during prone restraint and the importance of scene and history investigation in conjunction with autopsy and toxicologic findings.

In 1991, Kornblum and Reddy reported 16 fatalities of young men involving police confrontations where Taser guns were used (7). The Taser is a hand-held electrical control device that utilizes barbed darts connected by thin wires to a 9-V-battery pack that delivers high-voltage, very low amperage, pulsed current to cause immobilization through painful muscle spasm. In all cases, the police were called because of bizarre, and in some cases aggressive behavior. Most subjects died between 15 min and 1 h after Taser usage. All but three had either cocaine, methamphetamine, or phenylethylamine in their blood at time of death. Three died from gunshot wounds. Some of the others died while restrained, but not enough detail was given to identify cases that might fit into the syndrome of positional asphyxiation during restraint. Electrocutation was not the cause of death in any of the cases in the opinion of the authors, who believed that the common thread in such sudden, unexpected deaths while in police custody was drug use leading to bizarre behavior.

Cases 5 and 6 in the current series also involved electrical control devices. In case 5, a Nova stun gun was used. The stun gun was similar to the Taser except that the electrical shock was delivered via two short prongs, 2 inches apart. In case 6, first a Nova stun gun and later the antennae of a Taser were used. In neither case did the shocks appear to cause death directly, as several minutes of activity followed the shock application.

In 1992, the San Diego Police Department and the San Diego County Medical Examiner's Office issued a final unpublished report prepared by a custody death task force (8). The report was circulated throughout the United States to police departments that participated in a survey. The deaths of five men, aged 28–41, who fit into the syndrome of sudden death while restrained because of excited delirium were briefly summarized. In four cases,

police were called because of bizarre, violent behavior. In the other case, police were asked to help locate a mental health hospital escapee. All were agitated and delirious when placed in prone restraint by police. Two were hogtied in the back seats of police cars when they stopped breathing. One was handcuffed and tied to a gurney. One was handcuffed while prone, but methods of restraint were not further described. One was handcuffed with ankles bound, but whether or not they were secured behind his back was not detailed. In four of the cases, cocaine induced the acute psychosis. In the other, the acute psychosis was a manifestation of chronic schizophrenia. In one, a rapid pulse was described. One was documented to be hyperthermic. Two were noted to be sweating profusely and one was nude. Three of the deaths were certified as accidental and two were called homicides.

The San Diego Custody Death Task Force national survey results provided insufficient detail from respondents to comment on the number or frequency of "hogtie" deaths nationwide, but it did indicate that of the 142 police agencies that responded to the survey, 43 authorized their officers to use the hogtie procedure. On the basis of the task force findings, the San Diego Police Department has banned the practice of transporting subjects hogtied and prone in the back of police vehicles.

DISCUSSION

The 11 reported cases are summarized in Table 1. All of the deceased were male, ranging in age from 14 to 44 years. In all cases police were called because of wild, threatening, or bizarre behavior, and in all cases it took several people to control and restrain the subjects. In all cases they continued to struggle while restrained initially, and minutes later were noticed to be unconscious or dead. All subjects exhibited behavior that could be characterized as acute mania, acute psychosis, or, more descriptively, acute excited delirium. The duration of the observed delirious behavior ranged from ~6 h in case 8 to <1 h. In two cases, a racing pulse was documented. One case involved undressing, at least three involved breaking glass, and, in one, a slightly elevated body temperature was noted, but temperatures were not recorded in the rest of the cases.

All subjects were restrained in a prone position. Nine were hogtied when they lost consciousness: two in the back seat of police cars, five on the ground, and two on the floor. One was tied on a gurney and one was restrained by several officers manually holding arms and legs along with knee pressure on the back.

TABLE 1. Summary of cases

Case	Age	Reason police called	Method of prone restraint	Cause of delirium	Listed cause of death	Listed manner of death
1	29	Property damage	Hogtied in police car	Cocaine and alcohol	Acute cocaine toxicity	Accident
2	44	Property damage/knife	Hogtied in police car	Cocaine	Cocaine delirium/positional asphyxia	Accident
3	41	Man on freeway	Knee on back; hogtied	Methamphetamine	Drugged excited delirium	Accident
4	36	Threats/property damage	Hogtied on ground	Cocaine and narcotic	Cocaine/narcotic toxicity	Accident
5	34	Children taken hostage	Stun gun; wrists and ankles tied; knee on back	Cocaine and alcohol	Cocaine excited delirium	Accident
6	24	Violence in hospital	Tied prone to gurney; stun gun	Schizophrenia	Coronary disease/schizophrenia/stun gun	Undetermined
7	14	Self-inflicted injuries	Hogtied gurney/floor	LSD	LSD psychosis	Accident
8	28	Nude man with gun	Knee on back; arms and legs held	Cocaine	Cocaine delirium	Accident
9	37	Family taken hostage	Hogtied on ground	Mania/psychosis	Mania/positional asphyxia	Accident
10	37	Wild man attacking car	Hogtied on ground	Schizophrenia/amantadine	Amantadine overdose	Accident
11	33	Wild man on street	Hogtied on ground	Cocaine and alcohol	Cocaine toxicity	Accident

Cocaine toxicity appeared to be the primary factor causing the excited delirium in six cases. Acute delirium as a manifestation of underlying chronic psychosis occurred in three cases. LSD and methamphetamine precipitated the acute delirium in one case each. A high toxic level of amantadine was found in the blood of one schizophrenic. Amantadine has been reported to cause psychosis, confusion, hallucinations, aggressive behavior, and seizures at toxic levels (9) and may have precipitated the delirium.

The wide variation in terminology used to certify the causes of death reflects the multiple factors that appear to culminate in these deaths. Psychoactive stimulative drugs, especially cocaine, can precipitate an excited delirium. An acute exacerbation of a chronic psychosis can do the same. Sudden death in agitated, manic psychiatric patients has been recognized for many years. The cause of such deaths has been postulated to be neurally mediated cardiac arrest. Such deaths have been seen both in patients and in animals placed in restraints (10). Drugs such as cocaine and amphetamines can, of course, cause death without positional asphyxiation from restraint as a factor, but the frequency of sudden death in people restrained prone while in a state of excited delirium, compared with the rarity of sudden death in such people when not restrained, implicates restraint as a causative factor in such deaths.

CONCLUSIONS

Sudden death of people who are in a state of agitated delirium during prone restraint appears to be a not uncommon phenomenon that has been recognized for years but infrequently reported in the medical literature.

The mechanism of death appears to be a sudden, fatal cardiac dysrhythmia or respiratory arrest induced by a combination of at least three possible factors relating to increased oxygen demands and decreased oxygen delivery. First, the psychiatric or drug-induced state of agitated delirium coupled with police confrontation undoubtedly places catecholamine stress on the heart. Second, the hyperactivity associated with agitated delirium coupled with struggling with police and against restraints undoubtedly increases the oxygen delivery demands on the heart and lungs. This is supported by the several cases where rapid pulses were documented. Finally, the hogtied position clearly impairs breathing in situations of high oxygen demand by inhibiting chest wall and diaphragmatic movement. Reay et al. reported a case where a hogtied subject exclaimed that he couldn't breathe just before he suffered cardiac arrest (1). Case 11 is similar in that the subject cried out that he couldn't breathe just before dying.

The mechanism of death in these cases falls into

the category of positional asphyxiation. The subjects are made more susceptible to sudden death during prone restraint by their condition of excited delirium. In that regard, their deaths are similar to other positional asphyxiation deaths commonly seen in neurologically compromised people, such as epileptics or people rendered stuporous by alcohol or drugs, who fall into positions that restrict breathing.

In all but one of the reported cases, and in most of the San Diego cases, the manner of death was certified as accidental. It seems reasonable to consider these accidents rather than homicides since prone, hogtied restraint was not generally considered "potentially lethal force" by most police departments in the recent past.

As information about the potential lethality of prone restraint in excited, delirious people has been disseminated, some police agencies have eliminated hogtie restraints as a means of controlling violent subjects. In light of the possibility of sudden death, it seems both humane and prudent to develop some safer means of control and protection. Devices are currently marketed for allowing full restraint of subjects while they are in a seated position. At a minimum, prone, hogtied subjects should be closely monitored for vital signs while awaiting or being transported for medical care.

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Restraint asphyxia in in-custody deaths Medical examiner's role in prevention of deaths

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Abstract

In the United States, the office of the Medical Examiner-Coroner is responsible for investigating all sudden and unexpected deaths and deaths by violence. Its jurisdiction includes deaths during the arrest procedures and deaths in police custody. Police officers are sometimes required to subdue and restrain an individual who is violent, often irrational and resisting arrest. This procedure may cause harm to the subject and to the arresting officers. This article deals with our experiences in Los Angeles and reviews the policies and procedures for investigating and determining the cause and manner of death in such cases. We have taken a "quality improvement approach" to the study of these deaths due to restraint asphyxia and related officer involved deaths. Since 1999, through interagency coordination with law enforcement agencies similar to the hospital healthcare quality improvement meeting program, detailed information related to the sequence of events in these cases and ideas for improvements to prevent such deaths are discussed.

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1. Introduction

In California, by State law, the Department of Medical Examiner-Coroner is an independent investigative agency responsible for the official investigation of all sudden and unexpected deaths, deaths by violence or deaths under suspicious circumstances. Many states have laws extending jurisdiction to investigate deaths due to infectious diseases that constitute a public health hazard, deaths during therapeutic and diagnostic procedures, and case review before cremation. The medical examiner also has jurisdiction to investigate deaths during custody of law enforcement and justice agencies. Although the medical examiner in the United States is an independent agency, we work with law enforcement agencies in the investigating of homicide cases, including officer involved deaths and deaths while under custody.

In 1988, Reay et al. [1] first reported on an experimental study on the detrimental physiological effects associated with the "four point restraint" procedure, commonly known as hogtying or hobble restraint. In a subsequent paper in 1992, Reay et al. [2] reported on three cases of deaths from positional asphyxia after the victims had been placed in a prone position in the rear compartment of a police patrol car. O'Halloran et al. in 1993 [3] reported on eleven cases of sudden death of men restrained in a prone position by police officers. Nine of the men had been hogtied, one had been tied to a hospital gurney, and one was manually held prone. All subjects were in an excited delirious state when restrained. Three were psychotic, and the others were acutely delirious from drugs (six from cocaine, one from methamphetamine, and one from LSD). In a second paper [4] O'Halloran reported on two additional cases of deaths of psychotic patients under restraint.

In the Los Angeles cases reported in 1995 by Stratton et al. [5] two unexpected deaths occurred in restrained (hogtied) agitated individuals while they were being

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transported by advanced life support ambulances. Law enforcement personnel had placed both patients in hobble restraints. Toxicological analysis revealed non-lethal levels of amphetamines in one patient and non-lethal levels of ethanol, cocaine, and amphetamines in the other. Stratton et al. in 2001 [6] reported on 18 other cases of such deaths witnessed by emergency medical service (EMS) personnel. In all 18 cases, the individuals had been restrained with the wrists and ankles bound and tied together behind the back. Associated with all these sudden death cases was struggle by the victims against the forced restraint, followed by cessation of struggling with labored or agonal breathing immediately before cardiopulmonary arrest. Also associated were stimulant drug use, chronic disease, and obesity. The report noted that unexpected sudden death when excited delirium victims are restrained in the out-of-hospital setting is not infrequent and can be associated with multiple predictable, but usually uncontrollable, factors.

2. Death investigation – policy and procedure

In Los Angeles, the following standards, policy and procedure were established for investigation of such deaths: 1. Investigative aspect, 2. Autopsy and specimen analyses, 3. Management of cases, 4. Cause and effect analyses with the aim of prevention.

2.1. Investigative aspect

In-custody deaths include deaths that occur during apprehension by police officers, and deaths while the subject is detained or incarcerated in a public institution. When death occurs under these circumstances, it is the duty of the Medical Examiner-Coroner staff to respond to the scene, take charge of the body, and investigate the circumstances surrounding the death. These situations often trigger accusations and emotional outbursts by the family members and community activists, and can also lead to litigation. Investigations into the cause and manner of these deaths, therefore, require sensitive, timely and thorough processing, since it is expected that scrutiny by investigative agencies, the media, and the public as well as the families will follow. In Los Angeles County, the team approach is used in handling these cases. Such deaths raise the question of the use of excessive force, procedures which are illegal, or have high risk of causing injury or even death, so the inquiry extends into the possibility of illegal acts of commission or omission of the police department in restraining the arrestee, resulting in death.

The police department is often concerned about undue lawsuits against the department and criminal prosecution of the involved police officer. The Medical Examiner's role in these cases is to handle them with sound, thorough investigation by a systematic process of observing, recording, gathering and preserving evidence and information and by subsequent analyses of the data with the goal of

rendering a cause and manner of death, and to communicate with the police department to elucidate the cause and mechanism of death, and provide the key information for prevention of similar deaths in the future.

2.2. The standard autopsy procedures

A well-qualified forensic pathologist is assigned to conduct such autopsies. The external examination should be meticulous. The pathologist should note and record even faint subtle bruises and abrasions. They may later become important, correlating circumstantial investigative findings with injuries, particularly the time of injuries. The direction of force of abrasion may become a crucial issue. Equal importance should be placed on any absence of injury on the head, neck, upper extremities as well as the lower extremities and the genitals. If there is any evidence of physical contact to the decedent, it is presumed that the contact may be the lethal act and all caution should be taken to properly document it. For the examination of the neck, it is important to look for petechial hemorrhages in the conjunctivae and the buccal mucosa in conjunction with hemorrhages in the neck. It should be noted that any injury or existing natural disease could act in concert with or be contributory to the cause of death. Complete and thorough detailed documentation of all findings is essential as the basis of assigning the proximate cause of death. Special procedures to be followed for reducing the chance of missing important findings include:

- (i) Multiple photographs should be taken to document each injury with a ruler.
- (ii) To compare the pattern, photographs should be taken at vertical angle.
- (iii) Photographs should include whole body/all aspects.
- (iv) Photographs may need to be enlarged to see the details, so use fine grain negative film with adequate lighting, so that magnification can be done without loss of resolution.
- (v) The medical examiner should collect samples of hair, fingernail clippings, oral/genital swabs and preserve clothing and other articles that may be related to the death. These items should be placed in properly aerated containers to prevent decomposition of the biological evidence.
- (vi) X-ray of the neck should be taken, even if externally negative. For further detailed study, postmortem vertebral artery perfusion is recommended.
- (vii) Save adequate specimens and conduct toxicology studies including carboxyhemoglobin, volatiles, and drugs of abuse as indicated
- (viii) Where indicated, microscopic studies on heart, lung, liver, and kidneys should be conducted to assess existing disease.
- (ix) Specific attention should be directed to injury areas to estimate time of injury. Meticulous documentation and correlation of the injury should be included.

- (x) For assessment of finer neuropathologic changes, the brain and spinal cord should be fixed and examined by a neuropathology consultant as warranted.

In cases of death in prison or jail, in order to understand the incident better, it may be necessary to obtain information from the victims custodian and other inmates. Prison riots and gang activity may also result in deaths in prison custody and are important factors in coming to a conclusion.

2.3. Management of the case

For overall management of the investigation with focus on the search for reliable information and rendering a reasonable conclusion, a number of points need to be understood. There may be pitfalls in in-custody death investigation. The final conclusion may have a great impact on the community and agency policy making, so it is important to use caution in recognizing injury as the primary or contributory cause of death. If injury contributes to death, the death is assignable to the injury event, regardless of the nature and extent of an existing primary natural disease. Careful assessment to evaluate whether events are coincidental or related must be on “the scale” used to assess the death. Premature and inappropriate release of information to a suspicious public may result in suspicion of unwarranted and inappropriate conduct by authorities. At the same time, it is more harmful not to release information that may often be interpreted as concealment of misconduct. Before release of information, all work and evaluation should be completed, but it must be in a timely fashion. Conclusions must be circumspect.

In Los Angeles County, when the manner of death is classified as homicide, this only means that a person died as a result of a direct action of another person. It means the death was at the hands of another. Further note that the term murder is a legal classification that should only be used by charging authorities, i.e., the district attorney.

2.4. Cause and effect analysis and special consideration

Assignment: The in-custody death investigative team is assigned to investigate such cases at scene. The Chief Medical Examiner-Coroner and the Chief of Forensic Medicine Division will conduct the final reviews. In order to review those cases, it is necessary to be able to reconstruct the scene.

Necessary documentation: At-scene investigation of the undisturbed body is necessary. If paramedics have removed the body for emergency care, it is necessary for the medical examiner to review all photographs and descriptions of the scene taken and provided by the investigating agencies. All available preliminary information is taken into consideration before the autopsy is performed, but all information must eventually be confirmed. The records of the police agency are reviewed, including all statements of persons

who witnessed the event and persons who were in proximity to the scene of death.

Information on restraints in detail: If physical restraint was used, a detailed description of the method of restraint is necessary. The description should include: (a) what type of restraint, (b) what period of time, (c) position of victim when the restraint was applied and during the restraint period, the final resting position, (d) any use of arms, shackles, handcuffs, flexcuffs, choke hold, the use of taser, pepper spray or any additional restraints, such as hogtying.

Approach in investigation of in-custody deaths: The Los Angeles Office looks at the types of restraint measures used, which can include the use of pepper spray, taser, swarm techniques, baton use, handcuffing, ankle restraint, four point restraint or hog-tying, etc. Investigation looks into whether or not these restraining procedures were applied separately, intermittently, or together. It is important for us to also know how many officers were involved in apprehending or subduing a suspect who required restraint or use of force. We then look at how long and what types of restraint measures were applied. We gather independent observations regarding the consciousness, mobility, and actions of the suspect during this process. When a victim had been taken to a hospital, we evaluate the paramedic report, the medical treatment and the hospital toxicology reports, and include obtaining the hospital blood for further toxicological analyses. The autopsy is most comprehensive for these types of cases and includes fluoroscopy and X-rays as needed. Neuropathology studies and microscopic studies are generally performed/supervised by one of our full time, Board Certified staff pathologists. During autopsy, we also look for injuries, preexisting medical conditions, and drug intoxication.

3. Medical examiner's role in prevention of death

The critical aspect in each case is the chronology of events. We rely heavily on independent observations, as well as the internal review process by the law enforcement agency. Paramedics should be reminded to take body temperature as part of their evaluation. In the past we have experienced difficulties in acquiring information due to the fact that officers involved in the apprehensions often exercised their Fifth Amendment rights against self-incrimination guaranteed by the U.S. Constitution. Typically, we experienced the following types of cases: During a “swarming” technique, several officers try to handcuff an unusually heavyset large suspect and apply ankle restraints. Often-times a baton is used to bring down the suspect and usually the suspect ends in a face down position often with officers kneeling on or sitting on the arrestee. Even though the actual “hog-tying” procedure may or may not have been a factor, multiple officers sitting on the back of an obese person can restrict his/her respiration. Hence the term, “restraint asphyxia,” is used to describe the cause of death in these cases. The role of the Medical Examiner is not only to determine the cause and manner of deaths, but also to take

action in informing the appropriate agencies to reduce unnecessary deaths and suggest appropriate actions for correction.

In Los Angeles County, the Chief Medical Examiner-Coroner (CME-C), noting these cases of deaths during or following police arrest procedures, communicated with an official letter to the Office of the City Attorney (Sathyavagiswaran, personal communication), informing them of the Coroner's Office procedures and findings, suggesting that the district attorney's office and/or the city attorney's office should institute an independent investigation or field a response team to check into the police arrest procedures resulting in these deaths. Further suggestion was made that in these situations paramedics should also be summoned at the same time as the police, so medical assessment of the individual disturbing the peace can be made immediately. These individuals are often under the influence of drugs and/or have preexisting medical conditions.

It was strongly suggested that these incidents be videotaped in entirety whenever possible. Videotaping is very useful for studying the activities of the victim before apprehension and the effect of the restraint maneuvers used. When restraint is used, it advised that apprehended suspects be placed in the lateral decubitus or sitting position and to avoid placing them in a face down position, placing weight on their back, and hogtying them. At the first sign of physical difficulty, take him/her to a hospital where specialists are available to evaluate and clear the person before he/she is taken to a jail facility.

Finally, the Medical Examiner suggested a multi-disciplinary team conference to evaluate the sequence of events, so there is consistency in information provided. A strong message was sent to the City Attorney's Office by the CME-C that hog-tying compromises lung volume and respiratory function and recommended the use of alternative restraint maneuver. In response to a grand jury recommendation, since October 1999 in Los Angeles County a multi-disciplinary team composed of representatives from the police departments, the sheriff's office, the district attorney's office and the Medical Examiner have met regularly in a forum to freely exchange information and ideas to address areas of mutual concern and improve the arrest procedure to reduce injury and prevent deaths.

4. Manner of death

Concerning classification for the manner of death, Los Angeles County Coroner's Office established the following standards for determining whether or not deaths following a hog tying incident should be determined as homicide or undetermined. In a joint meeting with the DA and police chiefs, the CME-C indicated that if the following combination of multiple factors is involved, the manner of death is classified as undetermined. The factors are (1) obesity and enlargement of the heart, (2) laboratory tests show drugs in the system, (3) psychiatric history and psychotic reaction, (4) high risk (unsafe) arrest procedure, (5) insufficient

information to explain the sequence of events, (6) either insufficient information or conflicting information which affects the Medical Examiner's ability to make a final determination. The Medical Examiner may determine the manner of death as undetermined as a signal to law enforcement that the case warrants more in-depth investigation to try to answer some of the questions surrounding the death. Undetermined is also used by the Department of Coroner when the autopsy findings do not establish any specific cause of death, such as the case of a young person without heart disease or other existing diseases, no drug in the system, yet dying following the restraint procedure. When the manner of death is determined to be homicide, it simply means the death was at the hands of another.

5. Discussion

5.1. Mechanism of death

There has been much discussion as to whether or not the prone position per se would cause death of a hog-tied individual. Reay et al. in 1988 [1] reported on the effects of positional restraint on oxygen saturation and heart rate, and noted that positional "hog-tie" restraint induced prolonged recovery time. He concluded that persons placed prone, handcuffed, and "hog-tied" expire as a result of the physiological effects produced by positional restraints and reported deaths of hog tied individuals were due to "positional asphyxia." Other reported cases of deaths of hog-tied individuals [2] all indicated that the hog-tied persons had been placed prone (face down) on a surface.

A Los Angeles County Coroner study (Rogers C, Russell MA, Eckstein M, Mallon W, Aguilar G, unpublished observations) monitored the heart rate and blood oxygen saturation of 10 subjects in four-point restraint in the hyper extended position, and compared this with restraint using two commercially manufactured restraint devices. Positional differences were studied. The subjects were placed in the prone and left lateral decubitus positions. Recovery of heart rate after exercise was significantly better with the limbs partly extended on the left side (left lateral decubitus position). Most subjects did not experience significant oxygen desaturation during restraint, although desaturation did occur in some subjects. The authors emphasized that four-point restraint in the hyper extended position is associated with potentially dangerous physiologic changes. The use of restraining devices that do not hyperextend the limbs was recommended.

Chan et al. [7] determined whether the "hobble" or "hogtie" restraint position results in clinically relevant respiratory dysfunction and concluded that, in a population of healthy subjects, the restraint position resulted in a restrictive pulmonary function pattern but did not result in clinically relevant changes in oxygenation or ventilation, although a small restrictive pulmonary function pattern by

pulmonary function test parameters was found in subjects who were placed in the restraint position.

Parkes [8] measured the effects of restraint positions on recovery rate from exercise in healthy individuals and concluded that physiological effects produced by positional restraints should be recognized in these deaths.

In a more recent study Chan et al. [9] reported that the prone maximum restraint position with and without 25 and 50 pounds of weight force resulted in a restrictive pulmonary function pattern, but no evidence of hypoxia or hypoventilation was noted.

In experimental studies, it is difficult to simulate the real police arrest situation and experimental studies done on healthy individual surely cannot reproduce the real situation. There is no disputing the fact that there have been a number of deaths reported of unusually agitated individuals enduring restraint by hogtying procedure in police custody. There are certain characteristics that distinguished these individuals, who died while hogtied in police custody. It goes without saying that hogtying is used by the police in controlling unmanageable irrational and violent individuals who may cause harm to themselves as well as to others.

Stratton et al. [6] delineated the factors associated with the sudden deaths of agitated individuals who are placed under restraint for excited delirium. These are the individuals who are often subjected to hogtying when a family member calls the police to help control the person.

1. "Associated with all sudden death cases was struggle by the victim with forced restraint and cessation of struggling with labored or agonal breathing immediately before cardiopulmonary arrest.
2. The findings were also associated with stimulant drug use (78%), chronic disease (58%), and obesity (56%).
3. The primary cardiac arrest rhythm of ventricular tachycardia was found in 1 of 13 victims with confirmed initial cardiac rhythms, with none found in ventricular fibrillation.
4. Authors indicate that unexpected sudden death when excited delirium victims are restrained in the out-of-hospital setting is not infrequent and can be associated with multiple predictable but usually uncontrollable factors."

Deaths of hogtied individuals are not attributable simply to hogtying. Multiple factors are involved. These individuals are already compromised by drug use and/or mental aberrations triggering other physical disabilities. Their uncontrollable actions force family members to call the police for help and the responding police use their training and procedures to subdue and control these individuals.

5.2. Innovative investigation technique

O'Halloran [4] presented an innovative approach by reenactment of the restraint procedure using the actual restrainer. Within a day of the autopsy the restrainer participates in reenactments of the restraint process, utilizing

live volunteers as subjects. The re-enactment is videotaped. Deaths associated with restraint often have non-specific autopsy findings. Timely reenactment of the circumstances of deaths associated with restraint can help death investigators to more accurately determine the probable cause of deaths in such difficult cases. Such cooperative studies on the step by step effect of the restraint process which led to the death can be educational and help to elucidate what should be avoided to prevent such deaths, similar to the quality improvement program for patient care in the hospitals. In Los Angeles County, videotaping is used during actual arrest procedures. In case of death, the video is made available for evaluation of the mechanism of death. The CME-C and chiefs of police are in regular contact, sharing pertinent information to effectively prevent repeated deaths by similar means.

5.3. Quality improvement approach to prevention of death

Because of the litigious atmosphere here, the police agency is often reluctant to provide the medical examiner with pertinent information related to the sequence of events leading to the death of a person under its custody. We propose that a new team approach be set up to prevention of similar deaths. Earlier, for decades a similar blaming atmosphere confronted the healthcare providers and facilities and doctors and hospitals faced repeated malpractice litigation that prevented more earnest exchange of information and setting up a program for improvement. Beginning in the mid-1970's in California, concerned physicians formed a multi-disciplinary team to evaluate the causes of preventable deaths, and made a concerted multi-pronged effort in improvement in the quality of patient care by implementation of quality assurance and setting up improvement forums for earnest exchange of fact finding and open discussion of problems without fear of information being used to harm doctors' and/or hospitals' reputation. This concept was found to provide the most effective way to prevent repeated similar complications and deaths. Any documentation under this provision will not be the subject of discovery for legal action.

5.4. Manner of death

So far, we do not have any national consensus on the manner of death in these specific types of police-involved deaths. Reay [10] recommended accidental classification. Hirsch in New York City [11] recommended homicidal classification when the restraint position constitutes use of a "potentially lethal force." However, most of the reported cases have involved young men in a state of "excited" or agitated delirium as a result of intoxication from recreational drugs or psychiatric illness. In addition, these individuals had often suffered traumatic injuries before placement in the restraint position. In Los Angeles we would use the undetermined classification for those restraint deaths with multiple contributing factors. In

California, O'Halloran [12] recommended certifying these cases as accident or, if a disease was the main factor, then certifying as natural. Many medical examiners determine the manner of such deaths to be accident, meaning that the event happened by chance, or unexpectedly; taking place not according to usual course of events. An accident results from an act that is lawful and lawfully done under a reasonable belief that no harm is possible.

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DEATH IN CUSTODY

Donald T. Reay, MD

The sudden and unexpected death of a person while under arrest or in police custody is a source of community concern. Unsubstantiated facts and rumors surrounding a death in custody have always possessed the potential for controversy, and major disturbances have erupted because of alleged police misconduct. Bereaved family, friends, and communities in general are all deeply concerned whenever such a death takes place.

Searching questions are frequently asked about such a death, including the following: Was unnecessary force used by the police in arresting the person? Was the person physically abused during transport or during interrogation after having been placed in custody? Such questions relate to possible acts of unlawful violence on the part of law enforcement personnel and raise the question of police misconduct. Equally disturbing questions can be posed concerning neglectful behavior on the part of law enforcement personnel, including the following: Was serious and obvious illness in the person ignored or overlooked by the police? Were legitimate complaints minimized or disregarded? Was needed medical attention given? Did someone fail to recognize the potential suicide or fail to heed a suicidal threat? What steps were taken to prevent the occurrence of such an incident? Did the authorities make their rounds sufficiently frequently? Was every reasonable means taken to protect the safety and welfare of the suspect or prisoner from any form of self-directed violence?

We must recognize that misconduct by law enforcement does occur, and that it is the province of the medical examiner or coroner to thoroughly investigate the entire course of events from the moment the

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police first have contact with a suspect until the time when death occurs. It is mandatory that any death that occurs while a person is in the control of law enforcement officials be promptly, thoroughly, and objectively investigated by the local medicolegal official, whether a medical examiner or coroner. As in all sudden, unexpected, unusual, or suspicious deaths, a competent medicolegal investigation of any death occurring in custody or in confinement is necessary to establish the cause and manner of the unforeseen death and to determine irrefutable facts that characterize and illuminate the events surrounding the death. Three major purposes are served by such an investigation: (1) rumors and speculation are put to rest; (2) wrongdoing by law enforcement is recognized for what it is; and (3) information may be developed that identifies situations and procedures that require correction or improvement.

THE INVESTIGATION

Scene and Circumstance

As in any death investigation, the circumstances of the death should be clearly established. Particular attention must be given to any altercation or interaction with law enforcement personnel or anyone else. The medical examiner or coroner should, if at all possible, be notified of the death when it occurs and make every attempt to examine the body at the scene.²⁰ This provides a unique opportunity to make a preliminary assessment about what might have happened, and it establishes communication with the agency in charge of the investigation. This becomes invaluable in synthesizing events surrounding the death and is particularly useful when trying to establish cause of death. If a scene response is not possible, the medical examiner or coroner must have access to investigative information, including photographs, to establish the position of the body when found, the time the body was found, and when the victim was last seen alive. This is particularly true if the body is found in a jail cell. Equally importantly, when death occurs during the process of arrest, it is critical that a minute-by-minute reconstruction of events be developed. This means that detailed statements of the participants must be obtained, and that a detailed sequential reconstruction of events must occur. This process should be done as quickly as possible, because delay will only distort events, and time has a way of molding perceptions of what may have transpired.

Autopsy

Few investigations in forensic pathology come under as much scrutiny as a death in custody. It behooves the pathologist charged with performing the autopsy to institute those procedures ordinarily reserved for deaths of homicidal violence. Even though the death may appear to

be uncomplicated, such as a suicidal hanging, too often there are community suspicions that something sinister has happened and that someone in the ranks of law enforcement is responsible for the death. Consequently, the pathologist responsible for the autopsy must implement such procedures ordinarily reserved for homicidal deaths, to include the collection of trace evidence such as fingernail clippings, hair, and fibers; swabs for sexual activity; preservation of clothing; and complete and detailed photographs of any anatomic findings demonstrated at autopsy. There are never too many photographs. Consideration should likewise be given to the use of a video camera to record the entire procedure. On occasion it may be necessary to preserve critical specimens such as the larynx for future reference. Furthermore, it may be necessary to request consultation with physicians in other disciplines such as neuropathology. The most important feature of this aspect of the investigation, namely the autopsy, is to establish as precisely as possible any anatomic injury or natural disease that may have been responsible for or, at least contributed to, the death. There may be instances in which the anatomic findings are so definitive—for example, rupture of an acute myocardial infarct—that the investigation rapidly comes to a close, but this is most unusual. Ordinarily, with the autopsy the investigation is just beginning, and many hours will be spent reviewing reports of investigation before the certifier of death, whether medical examiner or coroner, has sufficient information to render a final opinion.

Concomitant with the autopsy findings, a complete toxicologic examination is required. Alcohol and street drugs, such as cocaine and methamphetamine, are common companions in victims who die in custody. Equally important are therapeutic drugs such as lithium and phenytoin, which may be present in subtherapeutic amounts and which may provide insight into the behavior of the victim, particularly if there is a history of manic-depressive psychosis or seizures. Unrecognized diabetic ketoacidosis can be responsible for sudden death. Vitreous and urine glucose/ketones may provide the first indication that such is the case.

INSTITUTIONAL AND RESTRAINT DEATHS

There are clear differences between investigating a death in which (1) the victim has been found dead, usually in an institution or jail, and in which (2) the victim dies during or immediately after a struggle during which physical restraint has been used by the police. In an institutional death in which the prisoner or inmate is found dead, there is a different emphasis and direction in the investigation, in contrast to the death of a suspect who is wrestled to the ground and then is discovered to be lifeless. Each has its unique problems worthy of separate discussion.

Institutional Deaths

Few case studies of jail deaths have been done in a fashion that permits a comparison of data from different parts of the country. The earliest study performed in the Cleveland metropolitan area, by Adelson et al² in 1968, examined over 12 years the cause and manner of death of 91 prisoners who were found dead in jail. Of those 91 prisoners, 64% died as a result of natural disease and 25% as the result of suicidal acts. The remaining 11% died of injury that was either accidentally sustained or in which circumstances were not determined. In a more comprehensive study, Copeland⁹ in 1984 examined the deaths occurring in metropolitan Miami of inmates in detention over 27 years. In his series, 55.5% were the result of natural disease and 20.9% the result of suicidal acts. In 1988 Frost and Hanzlick¹² examined 53 deaths over 12 years and found that 57% were attributed to natural causes and 26% to suicidal acts. The balance of the deaths in these studies was the result of homicidal or unintentional lethal violence. In all studies, arteriosclerotic vascular disease and seizures were responsible for most of the natural deaths. Hanging by ligature accounted for almost all of the suicides, most of which occurred early during the period of the prisoner's incarceration. Additionally, natural deaths occurred in an older-age group, whereas suicides occurred at a younger age. A most interesting finding in the Cleveland study, which was performed at a time when alcoholism was viewed as a criminal offense, was that two thirds of all sudden and unexpected deaths were the direct result of the sequelae of alcoholism either in its acute or chronic form. No recent studies have examined the character of sudden death in custody and confinement, particularly in view of the fact that alcoholism is no longer viewed as a crime, but as a medical condition that is treated, accordingly, in a proper medical or substance abuse and alcohol facility.

The Investigation

When a prisoner or inmate is found dead in confinement, the usual response by security personnel is to sound the alarm for immediate medical aid. It may be the policy of the institution that all security personnel are adequately trained in cardiopulmonary resuscitation and to immediately render aid. Although such aid may be given, recognition has to be given to the panic of the event, and to the injuries discovered at autopsy that may have been inflicted by resuscitation. Sometimes there may be reluctance of security personnel to render aid, and they may elect to wait for an emergency response by medically trained personnel. In both instances, the record should reflect what course of action was taken and who did what and when. As is the usual course of events with any emergency response, the victim is likely to be transported from the scene of death to a medical facility to receive definitive and appropriate care.

Emergency life-saving resuscitative procedures can produce injuries

that must be recognized at the time of autopsy examination. Similarly, how the body was handled and whether any injuries can or did result from such handling should be established. Of particular note is the hanging suicide and the manner in which a body is removed from a ligature. Skull fractures and scalp lacerations can be produced when the body is cut down and allowed to drop to the floor. Hence it is important that the circumstances and method surrounding body removal be known. Additionally, intubation, particularly by paramedical personnel, can produce injuries to the mucosal lining of the larynx that can be misinterpreted at autopsy as evidence of neck compression (Fig. 1). It behooves the medical examiner or coroner to obtain as much information as possible about the discovery of the body, attempts at resuscitation, any therapeutic procedures that were undertaken, and the handling of the body, whether in the hospital, emergency room, cell, or institutional dormitory.

As previously stated, opportunity to visit the scene where the incident occurred is of great value to the medical examiner or coroner. In addition to the actual site of death, the institution where the death occurred will generally have a log of the inmate's activity, as well as a record of activity of those responsible for supervising the inmates of the

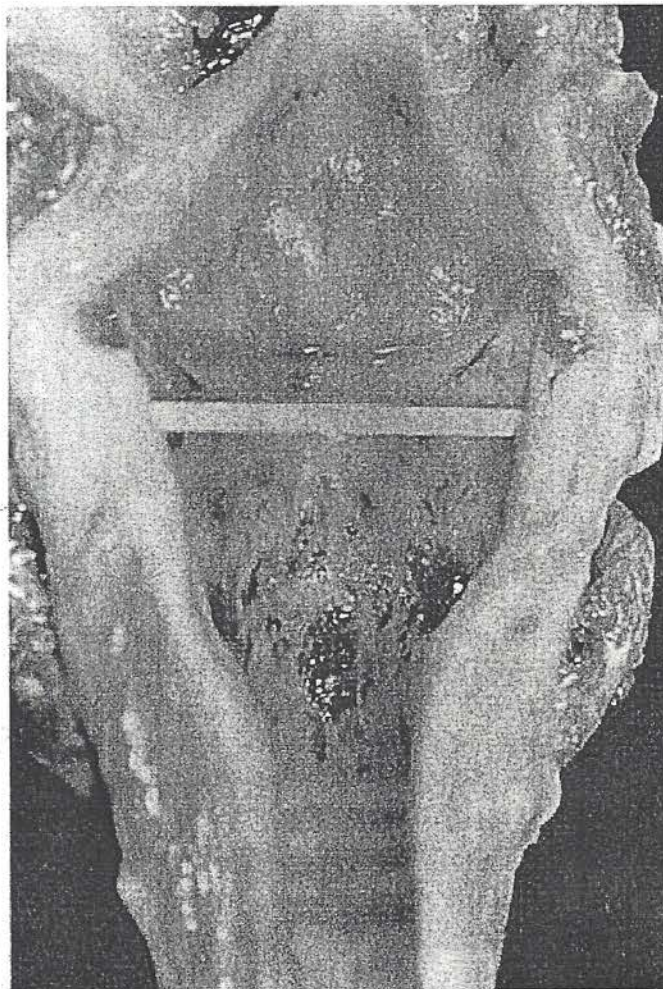


Figure 1. Mucosal hemorrhages produced by on-scene intubation by paramedics. The victim died of gunshot wounds.

institution. These records may be of some importance to those responsible for reviewing procedures or assessing liability, but generally they have limited value to the person responsible for certifying death.

The record of investigation must clearly reflect, in as much detail as possible, what happened. In some jurisdictions, the medical examiner or coroner may have an investigative unit separate from law enforcement to conduct a separate investigation. This is unusual, and most medical examiner or coroner agencies rely on law enforcement personnel to conduct the investigation, which obviously has the potential for concealing what might have transpired, but this may be all that is available. If investigative reports are not accessible, then the medical examiner or coroner is left with only the results of the autopsy and toxicologic examination on which to base an opinion of cause and manner of death. Occasionally, this may be all that is necessary—particularly if an overwhelming natural disease is present—but this rarely is the case.

Although it may appear that the investigation of natural death is straightforward, the person responsible for establishing cause of death should be circumspect during the death investigation. The cause of death may be convincingly established during the autopsy examination, but related issues may be difficult to assess and, furthermore, have significant civil liability. Even in situations in which the prisoner or inmate has been carefully monitored, there is always the concern that someone failed to heed the complaints of the inmate or failed to recognize someone who was seriously ill. It may be difficult to answer such questions based on the autopsy findings. Nevertheless, the examiner should be prepared to handle such questions. Regardless, you can be assured that there are many experts willing to step forward and offer opinions on the most meager of findings.

Although inmates who die from clearly identified natural disease may cause some concern, inmates who die by their own hand create major concern. Jail suicides have been studied in detail, and a well-defined profile has emerged of the person who takes his or her life while in detention.^{16, 30, 33} Hanging is the method of choice. This is understandable because the common and ordinary means that exist in the community, namely firearms and medication, are not readily available to the person in detention. Strips of fabric from clothing or bedding, belts, or shoelaces may furnish the means with which the desperate person can end his or her life.

Jail suicides, like natural deaths, always raise significant questions. Because these are violent deaths, a probing for a more sinister reason for the death occurs. The medical examiner or coroner must be wary and circumspect as the death investigation commences. An on-scene presence serves many purposes, most particularly the opportunity to examine the body at the scene (Fig. 2). At the scene the examiner has the opportunity to become informed of the vigilance of the caretakers or guards, the overall condition of the facility, and the spatial relationships at the site where death occurred. Because the majority of deaths

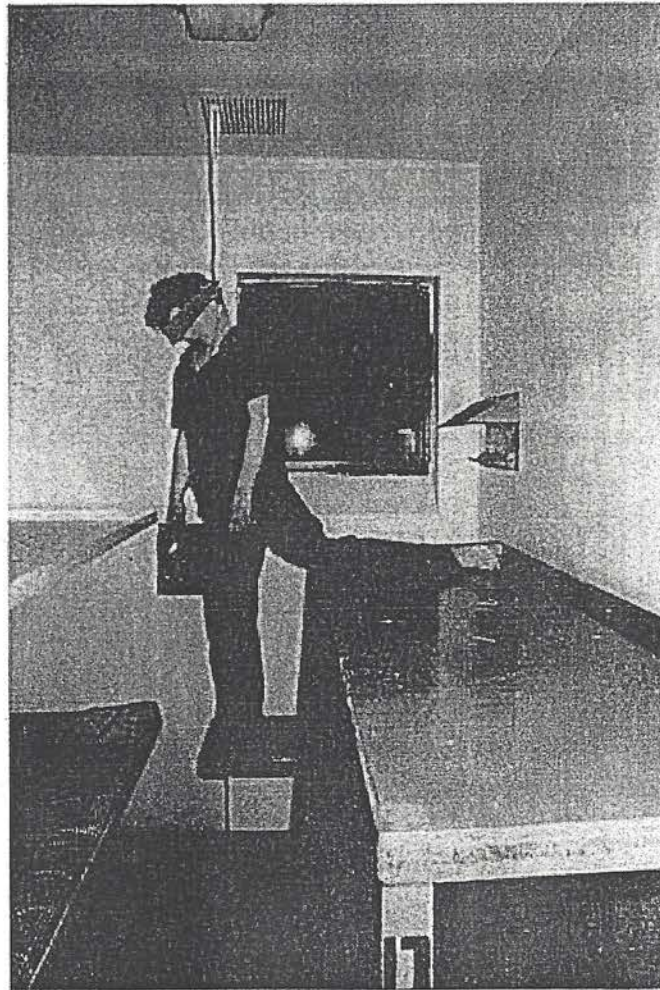


Figure 2. A typical jail death scene with victim using strips of cloth torn from a towel to hang herself.

are the result of hanging, the opportunity to reconstruct the method and means of self-destruction is also available.

One of the more frequent allegations in suicidal hanging deaths in custody and confinement is that guard(s) or caretaker(s) inflicted fatal injuries to the inmate, and that the ligature was fashioned to conceal lethally inflicted injuries, most notably manual strangulation. Although this may seem to be an untenable allegation, it is an allegation that can be difficult to contradict and must be taken seriously by anybody responsible for the investigation. Consequently, the autopsy should be approached much as a homicide investigation, because failure to collect specimens and to take detailed photographs of any injuries and to give appropriate attention to the ligature can only raise questions concerning the adequacy of the postmortem investigation.

The performance of the autopsy should present no particular problems for the experienced pathologist, but as in any asphyxial death, attention must be given to the performance of a careful neck dissection to assess the character of the injury present and, more importantly, to exclude other injuries commonly associated with manual strangulation or choking. Because the autopsy findings in hanging victims show some variation in their presentation at autopsy, it is worthwhile to review the

spectrum of these findings. Luke et al²³ studied hanging victims in a number of circumstances and described laryngeal fractures in about a third of the cases examined. More recent studies have shown a higher incidence than originally reported.⁵ The important point of both of these studies is that laryngeal fractures do occur and are not a point of differentiating manual strangulation or choking from a suicidal hanging. Additionally, petechiae of the bulbar and palpebral conjunctivae are variable and may be absent if the body is completely suspended. Petechiae offer little help in discriminating between a more nefarious act of murder and a self-induced hanging.

It is necessary to emphasize the importance of a complete evaluation for prior sexual activity during the examination of the body. This is particularly true for female victims, because there is the unspoken assumption that a female prisoner is vulnerable to sexual assault by male guards while in custody. Swabs should be taken of all body orifices and preserved for DNA analysis, along with the usual microscopic and chemical evaluation for the presence of semen. There is always an element of suspicion of sexual activity because the death occurred in confinement. In the male victim who is found hanging, some urethral seminal discharge can occur after death and is not a reflection of sexual activity before death.

Release of Information

One of the more difficult determinations for any medical examiner or coroner is the release of information concerning a death in confinement. My experience is to release as much information as possible, because to withhold information only creates an atmosphere of suspicion. If the cause of death is clearly established, it serves no purpose to conceal that information from the public. It may be prudent, however, to avoid releasing details concerning the death. This information may be a mix of hearsay and fact, and it may place other agencies in a difficult position to explain events, particularly during the early phase of the investigation. It may be necessary to answer queries by stating that other studies are being conducted and to specify these studies and why they are being performed. Once an atmosphere of withholding information about the death is created, it becomes difficult to generate a sense of truthfulness and to remove the suspicion of "cover-up."

Death on the Street

Of all the deaths that a medical examiner or coroner is charged with investigating, the most difficult and complex are deaths that occur on the street while a suspect is being detained or placed under arrest. The level of violence surrounding the event can be extraordinary and may be witnessed by a variety of individuals, including friends and relatives of the deceased. There have been occasions on which the entire confrontation has been recorded by a hidden camera of an amateur photogra-

pher. There is no question that such events frequently attract local and sometimes national attention and can cause police agencies to come under intense scrutiny. When such a death occurs, there is frequently a sense of community outrage about the conduct of the police, and occasionally criminal charges have been filed against law enforcement personnel involved. Such is the atmosphere that the medical examiner or coroner may face and in which a death investigation may be conducted. The police seek exoneration of their acts, while family and friends of the victim seek retribution for the death.

The Investigation. As previously stated, if there is a scene of death, the death investigator, whether medical examiner or coroner, should respond to the scene. Generally there will be no physical evidence at the scene to aid in the investigation, but the real value is the opportunity to develop a sense of what happened. It provides an opportunity to see the physical surroundings and terrain, establish the jurisdiction of the investigation, learn what method of physical restraint was used, and assess the overall level of violence that occurred. This awareness of the dynamics of the event can prove invaluable during the examination of the body. It directs attention to critical areas of the body that require a detailed examination, to either identify the nature and extent of injury or, equally importantly, to demonstrate the absence of injury.

Restraint Deaths

The types of physical restraint involved in police encounters that are generally identified as causing death include neck holds and mechanical restriction of respiration. Because each of these maneuvers may be responsible for death, each will be examined separately.

Neck Holds

Neck holds are a common method of restraint used by most police agencies throughout the United States. For many years the use of all neck holds was generally viewed as an acceptable, nondeadly maneuver that could be used in any confrontation. Generally, the choke hold, a type of neck hold, is viewed as inherently dangerous, because it is designed to obstruct the airway and to virtually strangle a person into submission or unconsciousness. The neck hold called the "carotid sleeper" or "lateral vascular neck restraint" is designed to obstruct the carotid arteries in the neck and cause momentary unconsciousness.⁶ Personnel who teach defensive tactics use the carotid neck hold as the primary hold to be used if the situation warrants its use. Those who are versed in martial arts can attest to the effectiveness of carotid compression. Physiologic studies performed in our laboratory have shown that carotid blood flow is significantly reduced in about 7 to 10 seconds when the hold is correctly applied.²⁹ This means that an officer can quickly gain control of his opponent during the period of temporary

unconsciousness. The difficulty of quickly and appropriately positioning the arm and forearm to occlude the carotid arteries in a violently struggling person may not always be easy.²⁸ What may be intended as a carotid submission hold can easily become a combination carotid submission and choke hold with devastating fatal consequences.

Autopsy Evidence of Neck Compression

Whenever there has been a fatal confrontation with the police, the pathologist is obliged to carefully examine the neck for signs of compression. Before the neck organs, soft tissue, and muscles of the neck are examined, it is particularly important that evidence of venous constriction of the vessels draining the head be evaluated. Because the jugular venous return of the head is a low pressure system, generally not exceeding 5 mm Hg, little pressure is required to occlude the veins and cause a back pressure to develop and extend to smaller vessels, namely venules, throughout the structures of the head including the eyes.¹⁷ If this back pressure is sustained, small vessels distal to the compromising stricture rupture and produce typical petechiae in the conjunctivae, buccal mucosa, and sometimes even the skin. The importance of petechiae is that they reflect increased pressure in the cervical venous system caused by constriction of veins, produced by compression of the neck. Petechiae can be produced by vigorous chest compression of resuscitation. This results from a retrograde venous pulse pressure from the chest into the venous system of the head. Nevertheless, the finding of petechiae is important, and it may be the first physically evident sign on the body to indicate neck compression.

The examination of the neck must include a meticulous surface examination to detect any contusion or abrasion. These findings may be subtle, meager, or sometimes nonexistent, but it is exceedingly important that the examination is detailed and even aided by a hand lens or a dissecting microscope. The absence of injury must be clearly noted.

As with the external surface examination, the underlying soft tissue, muscle, and neck organs must be examined in a methodic fashion, which has been appropriately described as a layered dissection of the neck.⁴¹ This examination must focus on the presence of hemorrhages in the soft tissue and muscles of the neck and, in particular, their character and distribution. It is unlikely that resuscitation ever accounts for hemorrhages in these areas. There may be the occasional instance in which hemorrhages in the submandibular gland result from the rearward thrust of the head during intubation or mouth-to-mouth breathing, but this area is located some distance from the major laryngeal structures that are directly affected by neck hold compression.

The most important examination of all neck structures is the laryngeal examination. Because the larynx constitutes the most rigid structure of the upper airway, pressure applied to the neck commonly results in fractures of the larynx or its appendages. Although the larynx is composed of three anatomic supporting cartilages—namely, the hyoid, thy-

roid, and cricoid cartilages—ossification begins early in life, but fusion of the cornu to the central body of the hyoid occurs much later and gives it rigidity and susceptibility to fracture when stressed.²⁵ It is imperative that these anatomic structures be meticulously examined to establish whether sufficient force has been applied to the neck to produce fractures. In some instances, the larynx may retain its cartilaginous character and remain pliable and less likely to fracture, but even in these instances there can be fracture of the cartilage with hemorrhage. A fracture to the larynx is good anatomic evidence that force has been applied to the neck.

In addition to injuries to the skeleton of the larynx, neck compression can produce scattered petechiae and flame-shaped hemorrhages of the laryngeal mucosa that can be randomly distributed over the surface. Even if the hyoid, thyroid, and cricoid structures are intact, such hemorrhages can occur and be the only evidence of neck compression.

Interpretation of Autopsy Findings

Once injuries have been identified to the neck, it then becomes the responsibility of the examining pathologist to offer a reasonable and reasoned interpretation of the findings. If there are fractures to the larynx—that is, the thyroid, hyoid, or cricoid, alone or in combination—the reasonable conclusion is that pressure was applied to the neck, usually in a constricting fashion. The author has yet to see such fractures induced by clumsy or difficult intubation during resuscitation. Isolated fractures can result from a blunt impact delivered to the neck with a nightstick, a kick with a shod foot, or even a karate chop. In such instances, however, the overlying skin will ordinarily show an abrasion or contusion as evidence of impact. It would be very unusual to produce bilateral fractures by such a mechanism.

In addition to fractures, hemorrhages of the soft tissue and muscle are the expected findings if neck constriction has occurred. In the absence of fractures, but with the presence of soft-tissue, laryngeal mucosal, and cervical strap muscle hemorrhages, and petechiae in the conjunctivae, neck constriction must be strongly considered, particularly if corroborated by events reconstructed through independent witness statements. As previously noted, confounding issues surface when there has been vigorous resuscitation. Intubation can produce hemorrhages (including petechiae) of the laryngeal mucosa, and vigorous chest compression can produce conjunctival petechiae. When this happens, caution must be used in offering a definitive pathologic diagnosis. The only hope in resolving such issues is to carefully examine the witnesses' statements of events, and to assess whether the narrative of events corroborates the anatomic findings. If there is a major contradiction, an assessment must be made of the reliability of the witnesses and whether the injuries present at autopsy could have been therapeutically induced. It is important that the autopsy findings be studied in the light of the record of events that is available.

Neck Holds and Death

Although constriction of the structures of the neck, in particular the carotid arteries, can cause unconsciousness very quickly, it does not mean that death immediately follows. There are instances in which death has occurred very quickly following the application of a neck hold, but to explain such a death requires the existence of a reflex neurologic mechanism such as the carotid sinus pathway. This mechanism is discussed in greater detail later. The most common pathway responsible for a neck hold death, however, is one of asphyxia, which is mediated by the lack of cerebral oxygenation because of restriction of the cerebral arterial blood flow or collapse of the airway.

How long does it take before there is hypoxic brain injury leading to death? The answer must be assessed in light of what we know about the survival times of victims who have sustained a cardiac arrest and have been resuscitated. There is sufficient clinical experience to assess how long cerebral circulation may cease to function, because of cardiac arrest or ventricular fibrillation, with survival and minimal residual neurologic effects.³² This clinical experience indicates that the limit for *occasional* recovery of function appears to be between 10 and 20 minutes. This is the reason for rapid institution of cardiopulmonary resuscitation, which is designed to reduce the amount of time the brain is without oxygenated blood. This critical time is important in evaluating deaths in which neck holds have been used. Furthermore, experimental animal data indicate that, with obstructive asphyxia, a similar 3-to-5-minute interval is required for cardiac standstill to occur. Death is not instantaneous.³⁷ Recognition must be given to the physical exertion associated with a violent struggle and the resulting fatigue and increased oxygen demands of the body, which may influence and shorten this interval. In evaluating deaths in which the neck hold is thought to have played a role, it is important that these references of time be kept in mind, particularly during the reconstruction of events surrounding the death.

Carotid Sinus Stimulation and Sudden Death

Sudden death may result from carotid sinus stimulation. This reflex neural pathway through the vagus nerve can cause bradycardia and cardiac standstill, and it may account for some deaths that occur rapidly following application of a neck hold. The sensitive carotid sinus syndrome is a well-recognized but uncommon clinical condition.⁸ Reportedly, some individuals chosen at random can be induced by neck massage into a bradycardia.⁴ This study suggests that a carotid sinus massage can create a reflex rhythm disturbance in a variety of persons who are not identified as "sensitive" to neck compression. This has significance in understanding deaths that have occurred during the application of a neck hold with immediate collapse and in which no significant pathologic findings are present at autopsy. Conceivably, even

though there may be airway and carotid artery constriction during the application of a neck hold, it does not preclude initiating the carotid sinus reflex and its attendant cardiac rhythm disturbance.

Restraint Asphyxia

In addition to neck holds, the other major consideration in evaluating deaths that occur during a physical confrontation with the police is the take-down of the victim, usually accomplished prior to the process of handcuffing, and the ultimate position of the victim after that restraint is accomplished. Because the event is so violent and dynamic, different aspects of the restraining process can be identified in evaluating deaths of this type.

Respiration depends on an intact airway, pulmonary parenchyma capable of adequate gas exchange, and the mechanical bellows action of the muscular and bony structures of the thorax. The coordinated activity of respiration is mediated by an intact nervous system. Obstruction of the airway by neck holds has been discussed previously, and diseased pulmonary tissue is a subject with which most pathologists are familiar. *Restraint asphyxia* describes interference with the bellows action of the chest that prevents an effective gas exchange from occurring and creates a condition of hypoxia that, if prolonged, can result in death.

Restraint asphyxia is a general term that encompasses all three components of the take-down and restraining process. These components include compression, restriction, and position. Each of these is likely to play a role during the restraining process, but it is difficult to assign a percentage value to each component.

Compression and restriction of the chest occur when the suspect is forced to the ground during an attempt to control the suspect. Usually this situation involves several law enforcement individuals who grapple with a suspect. Finally, resistance is overcome and the suspect is forced to the ground, where the police have the physical advantage and the opportunity to handcuff. During this process, compression and restriction of the thorax will occur if knees and feet are used to hold the suspect down (Fig. 3). Depending on the intensity of the struggle, it may take several minutes before the suspect is controlled by handcuffs, whether or not the feet are bound to the handcuffs in a hog-tied fashion. This process can be inherently dangerous, because compression and restriction of chest excursions create a pathologic condition akin to what is known as "traumatic asphyxia." In its most exaggerated form, this condition occurs when a victim is "pinned" by the collapse of a jack stand beneath an automobile, or in other situations in which a person's chest is compressed and immobilized, usually by a collapsing object.

There is a third component, namely the position of the victim, that must be evaluated whenever a person is placed face down and handcuffed, with leg restraints, whether or not hog-tied. Studies performed in our laboratory using oxygen saturation as an index to measure the effects of the face-down hog-tied position following exercise in volunteer

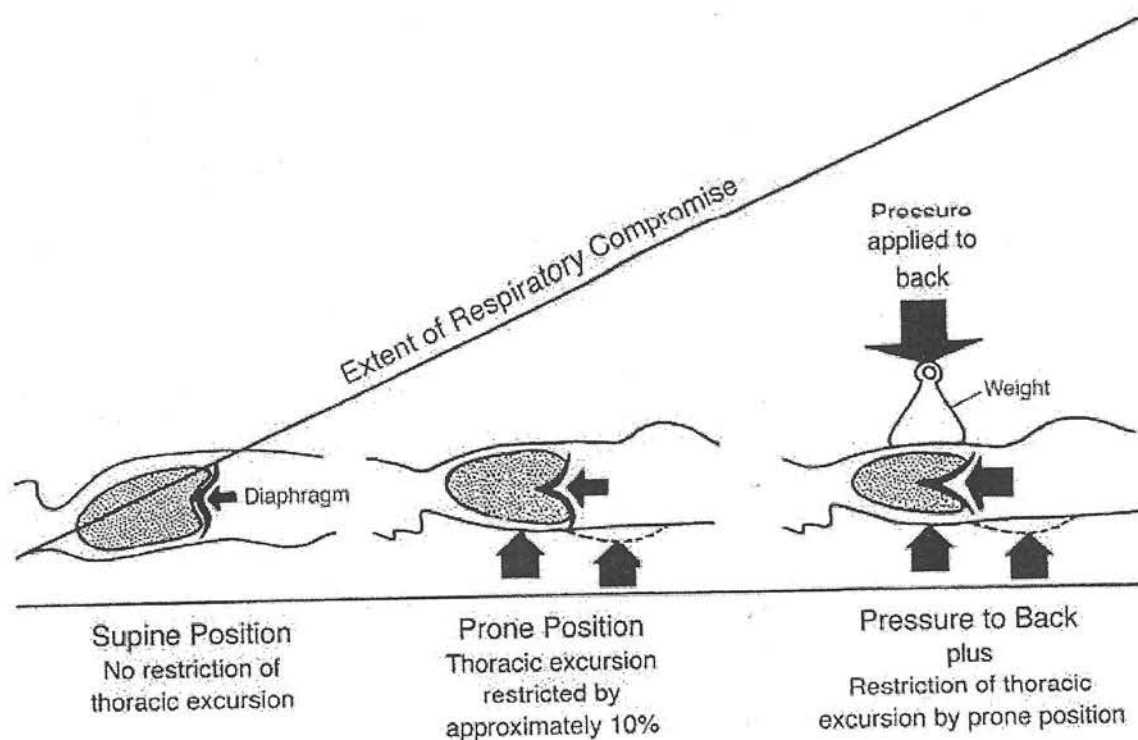


Figure 3. Restriction and compression of thoracic movement with weight placed on back in prone position. Abundant abdominal panniculus further impedes thoracic expansion by moving abdominal contents against diaphragm.

subjects showed a delayed recovery in oxygen saturation with the prone hog-tied position.³¹ We concluded that such a prone hog-tied position promoted a delay in respiratory recovery. This was viewed as potentially harmful because it interfered with respiratory recovery. More recent studies using arterial blood gas determinations refute our earlier work regarding the hog-tied prone body position. These studies show that although body position does not influence the respiratory recovery, there is an average reduction of respiratory excursion by 10% to 12%.²⁴ Hence in normal individuals, the hog-tied prone position should be viewed as not producing significant physiologic respiratory compromise, and it does not produce any serious or life-threatening respiratory effects. In some individuals, however, particularly those with an abundant abdominal panniculus, the upward movement of abdominal viscera against the diaphragm interferes with respiration and creates a situation of continued respiratory embarrassment. Similarly, if the chest is deformed by scoliosis or there is significant intrinsic pulmonary disease, the resting position of the victim must be viewed as interfering with respiration.

All three elements—compression, constriction, and position—need to be recognized in evaluating a death when a suspect is restrained face-down in the context of a violent struggle. When death appears to be the result of the take-down and struggle, with a number of people exerting pressure at various sites on the body, restraint asphyxia must be seriously considered in evaluating the death. The final resting position of

the victim must likewise be considered, as should body habitus and any unusual physical deformity, such as kyphoscoliosis.

Diagnosis. In contrast to the anatomic findings encountered when neck holds have been used, findings to support the diagnosis of restraint asphyxia can be meager to nonexistent. This can result when the force applied is not concentrated in one area to allow for well-developed bruising patterns to become manifest. Petechiae of the face and eyes can be expected if the compression of the chest is prolonged and severe; however, this finding may also result from neck compression. Vigorous cardiopulmonary resuscitation can generate enough retrograde venous pressure to produce petechiae. Fluidity of blood as evidence of asphyxia is an unreliable finding and should be relegated to the realm of useless information.¹

There are no typical pathologic findings that allow for a diagnosis of restraint asphyxia. The only source that provides the necessary information for this diagnosis is the historical record of events surrounding the physical struggle, take-down, restraint, and death. Because restraint asphyxia is a pathophysiologic process with few anatomic markers, the medical examiner or coroner must rely on events as described to understand and explain the death. The difficulty occurs when assessing the credibility of those persons who were witnesses to or participants in the restraining maneuver. The critical issues to be established are who did what and for how long. Equally important is a clear description of the behavior of the victim during the confrontation. Did the victim vocalize breathing difficulties or manifest signs and symptoms of distress with cyanosis or chest pain, or did the struggle end abruptly with the officers involved interpreting this as a sign that the victim "gave up"? After the struggle ceased and the victim was restrained, did the officers check the condition of the victim, or did they move away to recover their own composure and only later check the victim? These questions must be answered to create a timeline of events surrounding the death. Only after this information is established can the certifier of death make a judgment and render a statement of cause of death.

Catecholamine Rush

There is little doubt that where there is violent activity, abundant release of adrenal catecholamines occurs. The fight-or-flight response initiated by a violent physical confrontation and mediated by the adrenal medulla induces a pronounced output of noradrenalin/adrenalin, which are known to sensitize the heart and promote rhythm disturbances.⁷ Additionally, psychological stress has been shown to promote cardiac rhythm disturbances.²¹ These pathways play a major role in causing death in persons who find themselves in a perilous circumstance and suddenly "drop dead," with no clearly defined anatomic lesion to account for death. When there has been intense physical combat and the victim has been violently thrown to the ground, restrained with chest compression and restriction, and in some instances hog-tied to secure the

hands and feet, it is difficult to attribute death solely to a catecholamine response or a psychological stress-induced cardiac dysrhythmia. If death occurs when there has been respiratory compromise leading to hypoxia, the restraint maneuver must be identified as playing a major role in causing death. A similar circumstance occurs in exercise-induced sudden death when the autopsy fails to demonstrate a cardiac lesion. Such deaths have many features in common with restraint deaths because there are no identifiable pathologic lesions; however, attributing sudden death as solely exercise-induced during the physical confrontation and restraining process does not account for the dynamics of restraint and interference with the respiratory mechanics of the thorax. Restraint asphyxia is a pathophysiologic process that can only be described by the dynamics of the event and that is not demonstrated in tissue injury at autopsy.

Lethal Catatonia and Excited Delirium

Lethal catatonia is a term first used in 1934 by Stauder to describe death that occurred in mental patients, usually psychotic, who exhibited psychomotor excitement for several days to weeks with alteration in autonomic functions including fever, profuse perspiration, tachycardia, refusal to eat or drink, progression to rapid weight loss, dehydration, and death.³⁴ Autopsy examination failed to reveal any anatomic cause of death. The term *lethal catatonia* was created to describe these deaths. Other descriptive labels have been used and include "acute catatonic excitement," "psychotic exhaustion syndrome," and "malignant catatonia." More recently, "acute exhaustive mania," which appears to be similar to "lethal catatonia," has been suggested to explain sudden death occurring when an extremely agitated or psychotic person, in a drug-induced state or otherwise, manifests violent behavior and dies.¹⁹ Similarly, the neuroleptic malignant syndrome resulting from the withdrawal of antipsychotic/neuroleptic agents has many features in common with lethal catatonia. Some authors speculate that malignant catatonia and neuroleptic malignant syndrome are caused by hypodopaminergic states and are variants of the same process¹⁰ (EF Torrey, personal communication). In either instance, these two conditions have well-described clinical features that cannot easily be modified to explain sudden death, particularly when the victim is restrained with an element of respiratory compromise.

Cocaine-induced "excited delirium" is an acute drug reaction, first described as occurring in cocaine body packers by Wetli and Mittleman in 1981. These authors subsequently reported seven deaths in cocaine users who demonstrated bizarre and violent behavior.⁴⁰ Five of the victims required forcible restraint before death. The method of restraint is not clearly described and the restraint maneuvers not detailed. Nevertheless, a profile of the victim emerged, consisting of marked agitation, paranoia, and aggression characterized as "excited delirium" with unexpected strength and hyperthermia.³⁸ The amount of cocaine in the blood

at autopsy was lower than what is commonly seen in fatal cocaine overdoses. The consequence of these observations is that "excited delirium" has become a defined pathologic entity induced by cocaine and other stimulant drugs and which involves the dopamine system with central dopamine receptor blockade or neurotransmitter deficiency.³⁹ Because of these effects, akinesia of respiratory muscles has been postulated and may be the neurophysiologic pathway leading to death.¹⁸ If indeed this pathway affecting respiratory muscles exists, then any compromise of respiration, including position, may ultimately prove fatal. The consequence of "excited delirium" is that the victim may be particularly vulnerable to restraint-induced sudden death. This appears to be the condition reflected in the report of O'Halloran and Lewman,²⁶ which describes sudden death in 11 men restrained in a prone position by police officers during a state of "excited delirium."

Restraint, Natural Disease, and Drugs

To identify cause of death in situations in which there has been a violent confrontation with the police and in which the autopsy demonstrates significant natural disease and/or large amounts of drugs is one of the more taxing issues that the medical examiner or coroner faces. The restraint maneuver is unlikely to be *solely* responsible for the death if there is significant natural disease or drugs present. If there is every indication that restraint has played a major role in the death, it must be identified as such. It is virtually impossible to assign a degree or percentage of responsibility that restraint may have played in producing death. We may be able to distinguish various factors in a death and not be able to separate them. Consider the obese man with advanced coronary artery disease who is party to a violent confrontation in which he struggles desperately to evade the police, is finally handcuffed and shackled in a prone position, and then states that he cannot breathe. The autopsy demonstrates cardiomegaly with moderate focal coronary arteriosclerosis of sufficient severity to explain death under other circumstances. A dilemma exists that is not easily reconciled. Should the death be wholly and completely attributed to the natural disease process, or should the physical restraint be viewed as contributing to death? In this instance, the legal principle that you "take your victim as you find him or her" requires identifying the restraint process as playing a role in the death and therefore placing some responsibility on the police. The degree of responsibility is probably best left in a legal forum.

Similarly, the same circumstance arises when the autopsy demonstrates significant amounts of drugs in body fluids that under other conditions would be sufficient to explain death. This is particularly true for cocaine and amphetamine, where the amounts of drug present in the blood could be recognized as sufficient to cause death. Stimulants such as cocaine, however, appear to lower the threshold for death to occur during restraint. Animal studies shed some light on the role of cocaine in restraint; animals that receive high doses of cocaine and

are restrained are more susceptible to sudden death as compared to unrestrained control animals.²⁷ This experimental observation emphasizes the susceptibility of a person to sudden death during restraint if a stimulant such as cocaine is present. Whether that susceptibility is mediated by catecholamine is not established; however, deaths have been reported in persons with acute cocaine psychosis in association with face-down restraint, which probably includes chest compression and restriction.²⁶ The question is how much of a contribution did the restraint make to the death. Certainly the medical examiner or coroner can avoid any potential controversy and completely exonerate the police by summarily dismissing the restraint as insignificant and assigning full responsibility to the presence of drugs. I do not know how such dilemmas can be resolved, but the role of restraint and circumstances of the event should at least be recognized in an attempt to better understand and describe death in such circumstances.

Certification of Death

Obviously, the certification of death flows from the determination of the cause of death. The difficulties often encountered in establishing cause of death have already been discussed.²² If the natural disease process is overwhelming and the restraint maneuver is judged negligible after careful review of statements and the report of investigation, then an appropriate certification of the manner of death is natural causes. Similarly, if the autopsy findings demonstrate significant injury that can be attributed to the restraint process, such as injuries to the larynx, and reports of investigation show that significant force was used, including a neck hold, the death should be classified as non-natural and violent in character.

In assessing the death and establishing a manner of death, other considerations need to be evaluated, namely the inherent character of the injury or action that is viewed as responsible for the death. If the action by a person(s) is of such a nature as to be inherently dangerous and alone can cause death, and death results from that activity, then the death is appropriately classified as homicide. Because neck holds by their nature obstruct cerebral circulation or the airway or both, in addition to the potential of triggering a reflex parasympathetic cardiac standstill, they are inherently lethal. If death results following their use, then the death should be classified as homicide. Thus, in addition to viewing the death in the broadest sense of dying "at the hands of another," it is important to establish what the hands are doing to cause death. Similarly, if significant chest compression has occurred during the restraining process, particularly for an extended time, then such compression, sometimes referred to as "traumatic" asphyxia, is inherently lethal. If it is established that such a sequence of events occurred during the restraining process, a homicide classification is warranted.

The two examples cited, namely neck holds and chest compression, are more readily recognized as inherently capable of causing death. In

most restraint deaths, however, it is not easy to clearly identify the lethality of other activity that may play a dominant role in producing death. In the process of restraint—which involves placing a suspect in the face-down position—there are various components of this process that, because of the dynamics of the event, can be distinguished but not necessarily separated. If the chest compression and restriction are transitory (it is frequently difficult to establish specific times), then there should not be an inherent danger to life. Similarly, the prone position is a neutral position, largely tolerated by most persons even after vigorous exercise.²³ The situation is significantly altered when the condition of the victim creates a risk of sudden death. These conditions include intoxication by stimulant drugs such as cocaine and amphetamines, acute psychotic behavior (drug-induced or otherwise), physical exhaustion, obesity (particularly with a large abdominal panniculus), and the presence of significant cardiovascular or respiratory disease. Hence it is not only the transient restraint maneuver but also the condition of the suspect that creates the potential for a fatal outcome.

When certifying death in which restraint is identified in whole or in part as causing death, and the inherent character of the restraint used is not viewed as lethal in its application, then an accidental classification is appropriate. Some would disagree and use the broad definition of homicide in such circumstance as death occurring at the hands of another.¹⁵ Others would attribute death wholly to one of the many risk factors present in the victim, such as acute drug psychosis or exhaustive mania or others as discussed previously. Obviously, there are different ways of evaluating and certifying such deaths, which highlights the absence of any clear standard for assigning cause and manner of death occurring during a violent confrontation with the police.

PEPPER SPRAY AND CUSTODY DEATH

Oleoresin capsicum (OC) is an extract of pepper plants of the genus *Capsicum*. This extract is used as the active component of OC spray. OC is a complex mixture of capsaicinoids, 80% to 90% of it being capsaicin and dihydrocapsaicin, the most potent of the homologues in this mixture. OC is used as the principal active ingredient in pepper spray.¹⁴ Exposure to OC occurs through skin and eye contact and inhalation. When OC comes in contact with the skin, erythema and pain are produced. There are no reported instances of a chemical burn produced by OC, although OC enhances an allergic dermatitis. In the eyes, OC spray produces stinging, lacrimation, and photophobia. It decreases superficial sensitivity of the cornea and makes the eye vulnerable to abrasion. The respiratory effects are most pronounced. The nasal mucosa responds to OC with rhinorrhea, and low doses of capsaicin stimulate the cough reflex. Additionally, bronchospasm has been shown to occur in about a third of normal persons within seconds of exposure to OC.³⁵ Asthmatics are more sensitive to the bronchoconstrictive effects of capsaicin; an

acute asthmatic attack can be induced by exposure. In 1995, Steffee et al³⁵ reported two deaths in custody where OC had been used. In one death attributed to heart disease OC had been used, but the death was viewed as coincidental with the use of OC and not the consequence of OC. In the other death, OC exposure was identified as causing bronchospasm in a person with florid follicular bronchiolitis/bronchitis. In-custody death and OC has been reviewed by Granfield, Onnen, and Petty,¹³ who studied 30 deaths in an attempt to identify the role of OC as a causative agent. In all instances, death could be attributed to other causes, and none were identified as the result of OC. The use of OC has come under criticism in California by the American Civil Liberties Union, who identified 26 deaths thought to have resulted from pepper spray.³ Although pepper spray may have been used in each instance, the role of OC remains unclear. Pepper spray is widely used by law enforcement agencies, and at this time there is no convincing evidence to indicate that it is inherently lethal or dangerous.

SUMMARY

Death in custody is the most demanding investigation that a medical examiner or coroner can perform. The investigation requires attention to detail at the time of scene investigation and autopsy examination, as well as a careful assessment of the toxicologic results and circumstances of the death. Synthesis of the many facts that are developed during the investigation should allow the medical examiner or coroner to establish a reasonable cause of death. There can be legitimate points of disagreement of interpretation because the conclusions so frequently are predicated on physiologic processes and not on anatomic findings. It is incumbent on the medical examiner and coroner responsible for investigating deaths of these types to utilize all the information generated during the investigation and to identify an appropriate cause of death.

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Weight Force During Prone Restraint and Respiratory Function

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Abstract: Prone maximal restraint position (PMRP, also known as hogtie or hobble) is often used by law enforcement and prehospital personnel on violent combative individuals in the field setting. Weight force is often applied to the restrained individual's back and torso during the restraint process. We sought to determine the effect of 25 and 50 lbs weight force on respiratory function in human subject volunteers placed in the PMRP. We performed a randomized, cross-over, controlled trial on 10 subjects placed in 4 positions for 5 minutes each: sitting, PRMP, PRMP with 25 lbs weight force (PMRP+25), and PRMP with 50 lbs weight force placed on the back (PMRP+50). We measure pulse oximetry, end-tidal CO₂ levels, and forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1). FVC and FEV1 were significantly lower in all restraint positions compared with sitting but not significantly different between restraint positions with and without weight force. Moreover, mean oxygen saturation levels were above 95% and mean end-tidal CO₂ levels were below 45 mm Hg for all positions. We conclude that PMRP with and without 25 and 50 lbs of weight force resulted in a restrictive pulmonary function pattern but no evidence of hypoxia or hypoventilation.

Key Words: restraint, weight force, respiratory function

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Law enforcement and prehospital care personnel often confront violent, dangerous individuals who must be physically restrained to insure the safety of the individual, as well as those around them. A number of physical restraint tech-

niques have been developed to subdue and control such individuals in the field.^{1–3} The prone maximal restraint position (PMRP, also known as hobble or hogtie) position has been used extensively by field personnel. This position places a subject prone with wrists handcuffed behind the back, ankles bound together, and wrists and ankles secured together by means of a strap or other device.

Because of reports of the sudden deaths of individuals placed in this restraint position, controversy has arisen regarding the PMRP.^{4–7} Some have argued the position adversely impacts respiratory function and places individuals at risk for a so-called “positional” or “restraint” asphyxiation by restricting chest and abdominal movement.^{5,8} We previously conducted a study which found that PMRP by itself resulted in a small restrictive pattern on spirometry but had no impact on oxygenation or ventilation in healthy subjects.

It has been suggested that additional weight force pressure placed on the back of individuals during the restraint process can impede chest and abdominal movement further. Some have argued that it is this additional pressure on the torso, along with the PMRP, that causes chest and abdominal constriction and respiratory compromise leading to asphyxiation.⁹ In this study, we sought to investigate the impact of weight force on the back on the respiratory function and physiology of individuals placed in PMRP.

METHODS

We conducted a randomized, cross-over, controlled trial at a University Medical Center pulmonary function laboratory. Ten volunteer male subjects between the ages of 18 and 45 years were recruited to participate in the study. Potential subjects were excluded if they were unable to be placed in PMRP. No exclusion was made on the basis of pulmonary or cardiovascular disease or function, or based on body size and weight.

Each subject was placed into 4 different positions: sitting, PMRP with no weight force, PMRP with 25 lbs of weight force on the back (PMRP+25), and PMRP with 50 lbs of weight force on the back (PMRP+50). Subjects were placed in these positions in random order. For the sitting

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position, the subject sat in a chair with feet flat on the floor and back upright against the back of the chair. In the PMRP without weight force, the subject was placed prone on their stomach with head turned to the side on a medical examination table. The subject's wrists were bound together behind the back by means of law enforcement handcuffs. The subject's ankles were bound together and drawn up near the wrists by means of a police restraining cuff device used by local law enforcement, known as the maximal restraint cuff. In PMRP+25, the subject was placed in PMRP and a 25-lb sandbag was placed on the back of the subject between the scapulas. In PMRP+50, the subject was placed in PMRP and a 40-lb sandbag was placed on the back of the subject between the scapulas (Fig. 1). Subjects remained in each position for 5 minutes. After each 5-minute period, the subject rested in the sitting position for 10 minutes before starting the next trial.

Spirometric pulmonary function testing was performed at 1 and 5 minutes into each position for every subject. Measurements of forced vital capacity (FVC) and forced

expiratory volume in 1 second (FEV1) were obtained using a Medgraphics Cardiopulmonary Diagnostic System (Medical Graphics Corporation, St. Paul, MN) in accordance with the American Thoracic Society's standards for reproducibility and acceptability.¹⁰ Raw spirometric data were converted to percent predicted (%predFVC and %predFEV1) for each subject to normalize for height, gender, age, and race as per standard practice.¹¹

Oxyhemoglobin percent saturation (SpO₂) was monitored using a pulse oximeter sensor placed on the index finger (Ohmeda Biox 3740 Pulse Oximeter, Datex-Ohmeda, Helsinki, Finland). Expired end-tidal CO₂ (etCO₂) levels were monitored by means of a quantitative CO₂ detector using a Medgraphics Cardiopulmonary Exercise System CPX/D, Medical Graphics Corporation, St. Paul, MN). SpO₂ and etCO₂ measurements were recorded every 30 seconds during the 5-minute period for each position.

Statistical analysis was performed using an analysis of variance for repeated measures, with position and time as factors. A probability value of less than 0.05 was considered statistically significant. Data analysis was performed by means of a computerized statistical software package software package (STATA 6.0).

Clinically, data were also analyzed as absolute values in comparison with normal values defined prior to the start of the study. Hypoxemia was defined as SpO₂ less than 95%. Hypercapnia was defined as etCO₂ levels greater than 45 mm Hg. Spirometric measurements were considered abnormal if they fell below 1.65 standard deviations of established predicted values. The research design and methods of this study were approved by our University Human Subjects Committee and institutional review board.

RESULTS

All 10 subjects recruited for this study completed each of the 4 position trials. Subjects ranged in age from 21 to 40 years, and body mass index ranged from 21.3 to 35.3 kg/m². There were no exclusions of any participant or subject data. At 1 minute into each position, mean %predFVC was lower for all restraint positions when compared with sitting: 101% [95% confidence interval (CI) 91.6%-110%] for sitting compared with 87.1% [CI 79.7%-94.6%] for PMRP, 84.7% [CI 76.9%-92.5%] for PMRP+25, and 84.2% [CI 75.5%-93.0%] for PMRP+50. However, there was no difference in mean %predFVC in the PMRP or PMRP with additional weight force of 25 or 50 lbs (Fig. 2). Similarly, mean %predFEV1 was lower for all restraint positions when compared with sitting: 98.2% [CI 89.6%-107%] for sitting compared with 83.4% [77.6%-89.2%] for PMRP, 81.0% [CI 73.5%-88.6%] for PMRP+25, and 80.1% [72.1%-88.1%] for PMRP+50. Again, there was no difference in mean %predFEV1 in the PMRP with and without additional weight force of 25 or 50 lbs (Fig. 3).

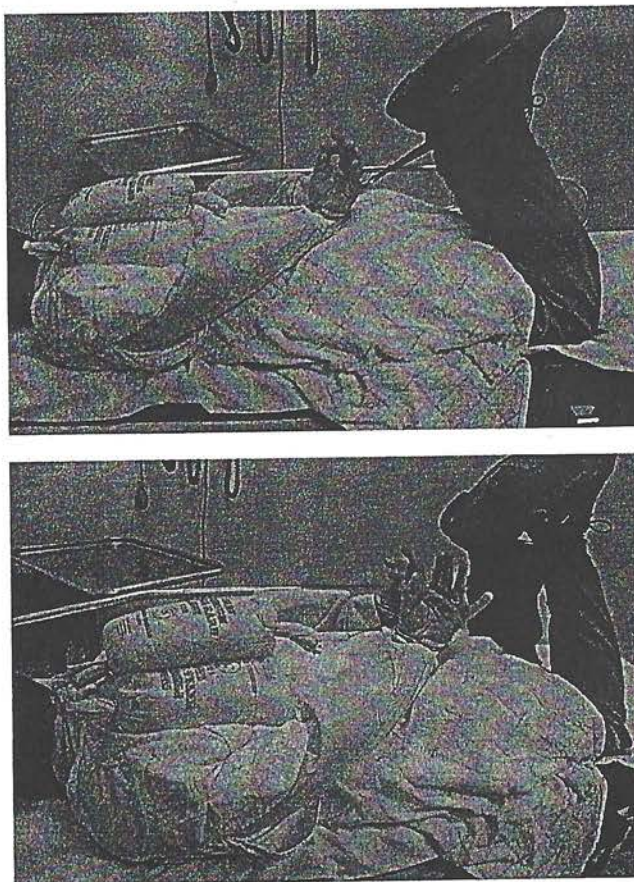


FIGURE 1. Top, Bottom, Subject placed in PMRP with weight force on back.

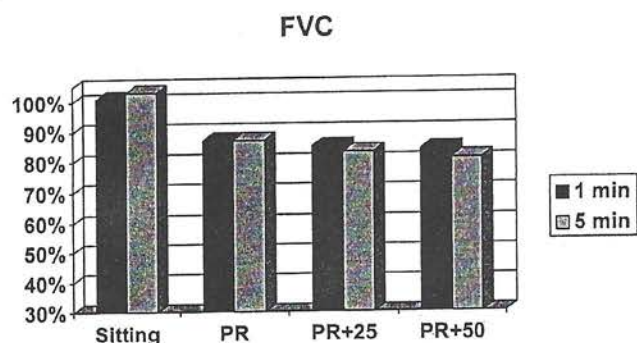


FIGURE 2. Mean %predFVC for subjects at 1 and 5 minutes into each position.

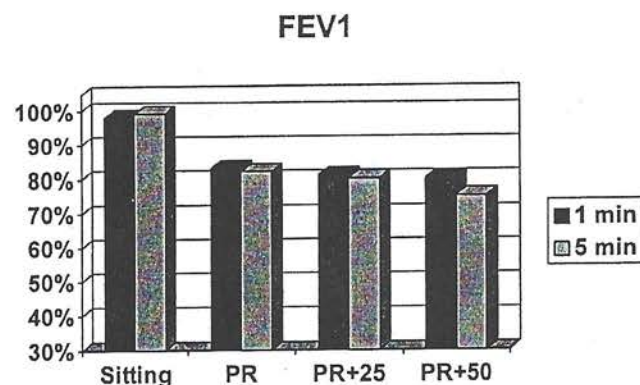


FIGURE 3. Mean %predFEV1 for subjects at 1 and 5 minutes into each position.

At 5 minutes into the position, mean %predFVC was significantly lower for all 3 PMRP position compared with sitting, but there was no difference between the restraint positions with and without weight force: 103% [CI 92.6%-112%] for sitting, 86.8% [CI 79.7%-93.8%] for PMRP, 82.5% [CI 74.0%-90.9%] for PMRP+25, and 80.5% [CI 72.5%-88.5%] for PMRP+50 (Fig. 2). Similar findings were seen for % predFEV1 at 5 minutes: 99.3% [CI 90.1%-108%] for sitting, 82.2% [CI 75.0%-88.9%] for PMRP, 79.5% [CI 70.9%-88.0%] for PMRP+25, and 75.0% [CI 66.6%-82.8%] for PMRP+50 (Fig. 3).

Clinically, mean SpO₂ levels remained above 95% and revealed no evidence of hypoxemia throughout the 5-minute trials for each position (Fig. 4). Similarly, etCO₂ levels remained below 45 mm Hg and revealed no evidence of hypercapnia throughout the 5-minute trials for each position (Fig. 5).

DISCUSSION

Although sudden deaths have clearly occurred in individuals placed in the hobble, hogtie, or PMRP, the cause of death and the actual role of body position remain controver-

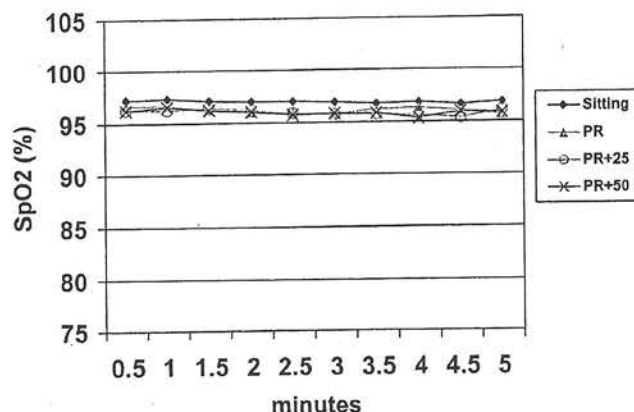


FIGURE 4. SpO₂ during each 5-minute restraint period.

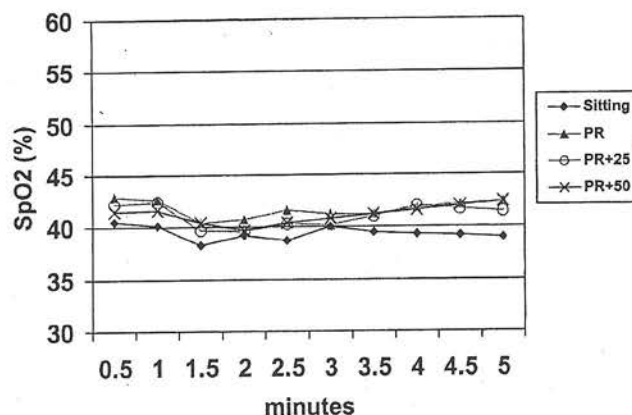


FIGURE 5. SpO₂ during each 5-minute restraint period

sial. Some have argued that the PMRP prevents adequate chest wall, abdominal, and diaphragmatic movement, leading to hypoventilatory respiratory compromise and risk for death from so-called positional asphyxia.¹² However, case reports and case series of the sudden deaths of restrained individuals do not clearly indicate a specific mechanism.⁴⁻⁷ Historical as well as autopsy evidence is often unrevealing as to a clear cause of death. Importantly, similar sudden deaths have been reported in patients who were not restrained in the PMRP, but simply in the prone, supine, lateral side, and even sitting positions.^{13,14} As a result, some have argued that factors such as drug intoxication, excited delirium, trauma, stress, and catecholamine hyperstimulation are more important causes of sudden death rather than asphyxiation from body position.^{15,16}

The theory of positional asphyxia as it relates to sudden deaths in restraint cases has been based primarily on the physiologic study of Reay et al,⁸ who found that healthy

individuals had a delayed recovery in oxygen saturation following mild exercise. However, this study was limited by the fact that a decrease in oxygen saturation was documented during mild exercise, in opposition to well-established exercise physiology work that has shown arterial oxygenation improves with exercise.¹⁷

We conducted a more comprehensive randomized physiologic study measuring arterial oxygenation as well as ventilation parameters, including spirometry and CO₂ levels. We found no evidence of desaturation or hypoxia during exercise or PMRP. More importantly, while there was a progressive restrictive pattern on spirometric measurements from sitting to supine to prone to PMRP positions, there was no evidence of hypoventilation or hypercapnia.¹⁸ Other studies have confirmed our spirometric and respiratory measures in relation to PMRP.¹⁹ Additionally, other investigators have not shown evidence of hypoxia or oxygen desaturation as a result of PMRP or restraint body position.^{20–22} As a result, many now argue that “the hog-tied prone position should be viewed as not producing significant physiologic respiratory compromise, and it does not produce any serious or life-threatening respiratory effects.”⁹

While body position by itself may not cause asphyxiation, others now argue that PMRP in combination with additional chest and abdominal compression during the restraint process could cause hypoventilatory respiratory compromise.⁹ Proponents of this “restraint asphyxia” theory (as opposed to “positional asphyxia”) argue that weight force often applied to the back of an individual restrained in the prone position during the restraint “take-down” process could potentially cause greater constriction of the torso and decrement in ventilatory function to the point of asphyxiation.²³

Deaths from the application of weight to the torso have been described in the medical literature.²³ The term *traumatic* or *mechanical asphyxiation* has been applied to cases in which extreme weight force was applied to individuals, such as when an automobile runs over the torso of an individual. However, in these cases, there is often pathologic evidence of chest trauma (pulmonary contusion, rib fractures) or increased intrathoracic pressure affecting venous return and cardiovascular function (plethoric facies, edema, and ruptured small blood vessels above the shoulders).²⁴

In this study, we sought to determine if additional weight force on the back of an individual in the PMRP resulted in any evidence of respiratory compromise or risk for asphyxiation. Similar to previous studies, we found a restrictive pulmonary function pattern with PMRP but no significant further detriment in spirometric measures of FVC and FEV1 with the addition of 25 and 50 lbs of weight force on the back. More importantly, we found no evidence of hypoxia, oxygen desaturation, hypercapnia, or CO₂ retention from hypoventilation in the PMRP with the additional weight force.

Our study has limitations. First, as this was a laboratory physiology study, we could not reproduce all conditions encountered in the field setting with such cases. In particular, we did not simulate trauma, struggle, drug intoxication, and other physiologic and psychologic stresses that commonly occur with individuals who are being restrained in the field setting.

Second, the amount of weights selected for this study may not reproduce the actual amount of weight force used on individuals during the restraint process. It is possible that heavier amounts of weights would have impacted respiratory function to a greater degree. Similar to traumatic or mechanical asphyxia cases, extreme amounts of weights could have resulted in significant chest wall trauma and marked elevations in intrathoracic pressure that could have impacted cardiovascular function. To our knowledge, this is the first laboratory investigation studying the effects of weight force during restraint. As a result, we chose weight amounts which we felt would approximate weight force used in the field setting, heavy enough to indicate any trends if respiratory function was impacted, but not so heavy as to potentially place our subjects at risk for injury.

CONCLUSION

We conducted a study on the impact of weight force placed on the back of individuals in the PMRP on pulmonary and respiratory function. We found that weight force of 25 and 50 lbs did not result in evidence of hypoxia or hypoventilatory respiratory compromise in our study subjects.

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Sudden In-Custody Death Syndrome

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This article discusses the existence of excited delirium in combination with other factors such as alcohol/drug use, physical condition of subject/patient, and the use of physical or mechanical restraints that could lead to a potentially fatal condition known as sudden in-custody death syndrome. The article reviews predisposing factors in combination with potentially hazardous actions by law enforcement and healthcare providers that have led to sudden in-custody death syndrome. It is up to those coming in contact with these subjects/patients who exhibit excited delirium states to be aware of the behaviors and further assess for other precipitating risk factors that may require further medical attention. **Key words:** *adverse effects, alcohol, asphyxia, cocaine, death, delirium, physical restraints*

RESTRAINT ASPHYXIA or positional asphyxia (asphyxiation death while in a prone position and hog-tied restraints in whole or in part from respiratory compromise)¹ (Fig 1) are terms generally used to describe a diagnosis after death when there are many contributing factors but the primary cause of death seems to be related to the restraint process. The concept of asphyxia due to restraint arose when it was recognized that being in the prone position could severely restrict breathing and compromise cardiac function in an agitated person.² Interference in the body's ability to breath (interaction of the chest wall, diaphragm, and muscles of the rib cage and the abdomen) causes a hypoxic state. This changes the body chemistry and can create a fatal heart rhythm.¹ In the mid-1990s, unexpected deaths while in custody

restraint where the autopsy and toxicology failed to lead to a definitive diagnosis were often labeled with "sudden in-custody death syndrome" (SICDS).³

Sudden in-custody death syndrome was first used to describe unexplained deaths when police were involved. It was first observed in 1982, when investigators in Seattle, Wash, described the sudden death of people in states of acute psychiatric agitation and hyperactivity when being restrained by law enforcement officers.⁴ These individuals exhibited a form of behavior disturbance that went beyond the distressed states that police generally encounter.⁵ The victims are generally described as being unusually aggressive. They do not respond appropriately to reasoning or commands and exhibit unusual strength. They inspire fear in those who know them; however, they are fearful themselves past the point of paranoia. They may be hallucinating and have a history of bizarre behavior, but the episode prior to death is far beyond their previous experiences (Table 1).

The police were notified because the subject was acting in a destructive manner, either to himself or his environment. The arrival of the police may worsen agitation. The paranoia of the manic person will be reinforced by the attempt of the law enforcement to make the person conform. This prompts further and more destructive behavior.

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Figure 1. Subject is in a hog-tie or suitcase restraint and placed in a prone position.

The mechanism of the spiral into the unusually aggressive behavior is unknown. The behavior may be precipitated by acute psychosis. The use of cocaine, methamphetamines, or phencyclidine, alone or in combination, may also help precipitate the event leading to SICDS. Alcohol and depressant drugs, statistically, may be involved but do not create the hyperexcitability required to create the excited delirium state. Another contributing factor named is the use of antipsychotic drugs, or neuroleptics (Table 2). Although neuroleptics may contain the psychiatric behavior of the patient, there are serious side effects. These include arrhythmias, vascular collapse, and asphyxia related to factors such as an impaired gag reflex and laryngeal-pharyngeal dystonia. Also known as neuroleptic malignant syndrome, patients suffering from this syndrome present in a manner

Table 1. Behaviors exhibited during the pre-death situation

Paranoia/mania
History of psychiatric issues
Extreme aggression
Unusual strength
Inability to respond appropriately to reason
Destructive behavior
History of drug abuse

Table 2. Contributing factor: Neuroleptics

Generic name	Trade name
Chlorpromazine	Thorazine
Thioidazine	Mellaril
Fluphenazine	Prolixin
Thioxanthene	Navane
Haloperidol	Haldol
Respiradone	Respiradol
Clozapine	Clozaril
Olanzapine	Zyprexa
Seroquel	

very similar to excited delirium. Physical exhaustion, dehydration, and organic brain disease are additional predisposing factors.

Symptoms include hyperthermia, fluctuating levels of consciousness, and hypotonicity.

However, while that may be one of the causes of a sudden death, it is not necessarily implicated in the exhaustive manic, and, in fact, may be a contributing factor to saving the life of the psychotic patient who may be heading toward the excitable delirium state. A syndrome of sudden death of psychiatric patients, called acute exhaustive mania, also known as lethal catatonia, was noted prior to the introduction of antipsychotic medication. Dr Luthor Bell at the McLean Asylum in Massachusetts first described the condition in 1849.⁶ The psychotic individual may also exhibit the signs of acute exhaustive mania without having used neuroleptics. It is contended that psychological stress can induce fatal cardiac arrhythmias. The psychotic individual with these symptoms is considered to be in a life-threatening emergency and the patient should be transported immediately to the emergency department. It is also noted in this article that psychiatric patients can be at risk for many health problems secondary to their living conditions. They may have preexisting cardiac disease, or general physical disability secondary to lifestyle. When the patient enters the state of excitable mania, the increased release of epinephrine and norepinephrine and the increased vagal and

Table 3. Excitable mania

Increased epinephrine release
 Increased norepinephrine release
 Increased vagal stimulation
 Increased adrenergic stimulation
 Increased myocardial excitability
 Eventual cardiac failure

adrenergic stimulation may increase myocardial excitability and lead to fatal cardiac arrhythmia (Table 3).

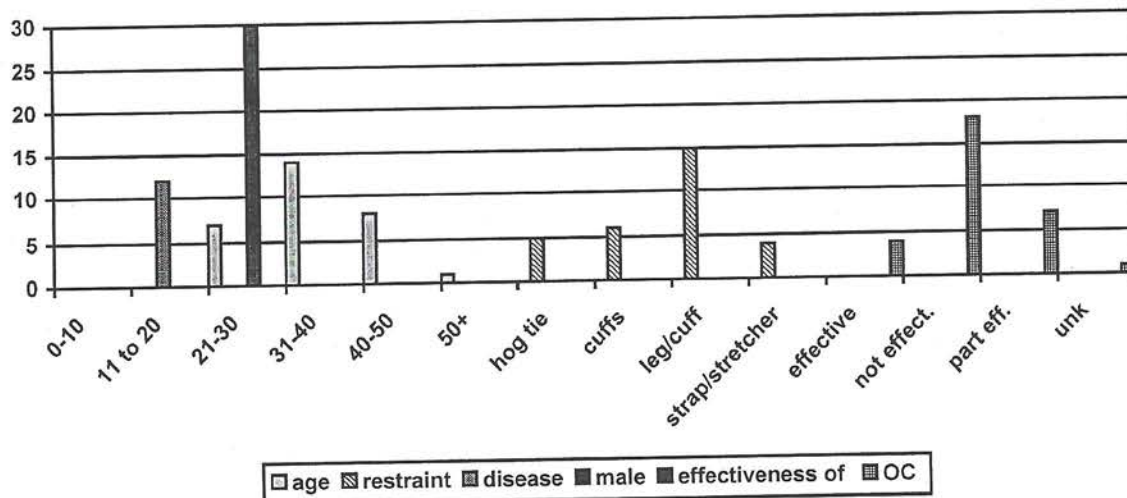
ELECTRICAL/CHEMICAL RESTRAINTS

Capsicum spray has also been named as a possible influence in the SICDS victim, without being the sole agent of the death. In 1991, the International Association of Chiefs of Police (IACF) issued an executive brief, "Responding to the need for a less than lethal alternative, police departments throughout the country have adopted Oleoresin Capsicum (OC) or pepper spray as a force option."⁷ When deaths began to occur after the use of OC spray, a task force was formed to provide data regarding the use of OC by police, and its influence in the death of persons in the excitable manic state. The IACF studied 30 cases over the period of 1990 to 1993 (Fig 2).

It was noted that in the majority of these cases, the OC was ineffective. All subjects behaved in a bizarre and combative manner and struggled with the police. The OC was listed in all cases as to be a noncontributing factor and not a cause of death. The cause of death in the majority of the cases was determined to be positional asphyxia, aggravated by drugs, disease, and/or obesity. Steffee et al determined that OC was an associated contributing factor in unexpected deaths among those exhibiting excited delirium, particularly those with heart disease.⁸

In the late 1990s, the use of taser stun guns became prevalent in law enforcement. Again touted as a safe way to restrain the combative or violent subject, it was believed that there would be a decrease in subject as well as officer injury. On October 12, 2004, *The Arizona Republic* published a list of 73 cases of death following taser stun gun use. Dating from September 1999 to October 2004, the commonalities are noted (Fig 3).

The use of restraint is mentioned only 29 times, but it would certainly make sense that it was used more number of times than the brief histories report. Obviously in all cases Taser was used. There is very little research regarding the effect of electricity in the subject in a excited delirium state. Certainly, in the situation of cardiac dysrhythmia, the use of electricity may contribute to the end lethal

**Figure 2.**

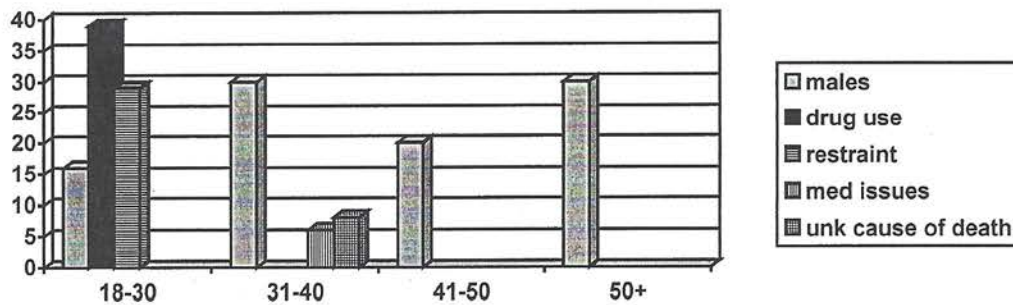


Figure 3.

result. It is of note that 11 of the 73 deaths seemed to occur immediately after Taser use.

In 1998, the *Canadian Medical Association Journal* published a study done on 21 subjects that fit the excited delirium criteria from 1988 to 1995 (Fig 4).

It was concluded from this study that people with cocaine use or psychiatric illness may require more oxygen and may suffer a rapid anoxic death if restraint is used.⁹

PHYSICAL RESTRAINT

A study done in Los Angeles County between 1992 and 1998 did not have many incidences of SICDS but of the 22 sudden death situations during that time, all were instances of the victim having been hobble restrained. One victim had a significant thrombosis and was excluded from the study. Another had ligature marks around the neck and was also excluded. The remaining 20 were found by EMS personnel in a prone position with hobble restraints on.¹⁰ Asphyxiation, the most com-

mon cause of restraint-related death, is termed "restraint asphyxia" in the forensic and emergency literature.¹¹ Restraint asphyxia is determined on the basis of the historical events leading up to the episodic event of physical struggle. Generally, the body's position interferes with respiration. In the forensic literature, usually the body was in the prone position not allowing adequate breathing. The cases of fatal positional asphyxia studied were those that had occurred in individuals transported in the prone position by law enforcement personnel.¹² However, other positions, including a bent neck with flexion toward the chest, and external airway obstruction or neck compression, where the victim was not able to release himself from the compromising position, have also been noted to be contributing factors¹³ (Table 4).

Upper-body holds (ie, the carotid hold and the choke or bar-arm control hold) are not commonly employed law enforcement techniques, and have been used for more than 30 years to subdue suspects resisting arrest

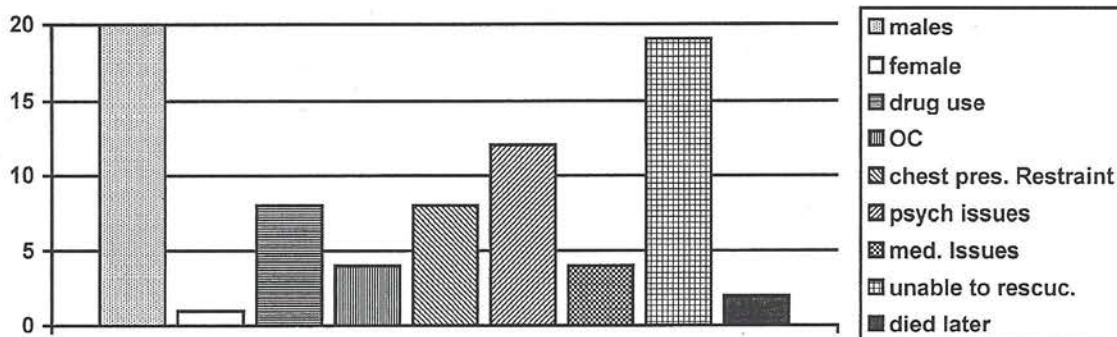


Figure 4.

Table 4. Positions contributing to death by restraint asphyxia

Prone position, hog tied Neck flexed toward chest External airway obstruction Neck compression

or to control combative behavior. The holds are intended to be used to render temporary unconsciousness, but not as fatal maneuvers. Pressure applied to the carotid artery area impedes blood flow, which could produce carotid sinus stimulation and result in bradycardia and cardiac arrest.^{14,15} Suffocation and aspiration may also occur in persons having an altered or decreased level of consciousness, interfering with their ability to protect their airway.

COCAINE USE

With cocaine use, the episode of excited delirium is most often seen at the end of one or more days of drug use. Cocaine levels may be low or undetectable. The effects of the cocaine on the brain's neurotransmitters lead to a loss of thermoregulatory control and alter the thought process. If the patient is not breathing rapidly, is not sweating, and is not tired after a struggle with the police, while the officers are all showing these changes, there is a high likelihood of impending collapse. Body temperature has a high correlation to a disordered central nervous system regulatory process, leading to a loss of thermal regulation and hyperthermia (Table 5).

Table 5. Signs and symptoms of impending collapse with cocaine use

Absence of tachypnea when patient should be breathing heavily secondary to increased activity Normal body temperature Lack of perspiration after sustained physical activity
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Table 6. Physiological changes with cocaine use

Disrupts dopaminergic function Precipitates agitation Delirium Aberrant thermoregulation Rhabdomyolysis Sudden death

Cocaine disrupts dopaminergic function and may precipitate agitation, delirium, aberrant thermoregulation, rhabdomyolysis, and sudden death (Table 6).

One of the organs that principally get targeted by cocaine toxicity is the heart. Cocaine is known to produce coronary artery spasm.¹⁰

In early 1994, Washoe County Sheriff's Department (Nevada) encountered a male subject who fit the criteria for excitable delirium (Fig 5). During the use of restraint and after struggle the subject died. The information was beginning to be disseminated throughout the United States regarding the SICDS and the problematic use of restraints. In response, the department created the policy that if subjects met certain criteria, they would be transported to area emergency departments and put under observation. Sheriff Diane Nicholson feels that this policy has greatly improved the quality of care given to the manic subject. They also changed the policy of prone restraint and hog-tying restraint. In spite of this, in August 2004, a male subject died in custody after a struggle with the police. According to *The Reno Gazette Journal*, August 20, 2004, the coroner's report stated the victim died of a heart attack secondary to methamphetamine use. Taser, restraint, and pepper spray were also used on this person.¹⁶ The victim died prior to EMS arrival on the scene. The fact remains that there are circumstances and times when, despite the police department's best intentions, death occurs. Consequently, officer awareness and recognition are necessary to ensure subject safety and minimize the risk of sudden custody death. With that

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Use this scale to help determine the need for closer observation. Begin at the first observed sign or symptom. Add the numbers for each sign or symptoms that applies.

Alcohol Intoxication	1
Acute Alcohol Intoxication	3
History of Alcohol Abuse	2
Cocaine Intoxication	4
Methamphetamine Intoxication	3
Drug Intoxication (other)	2
Antipsychotic Drug Use	2
History of Mental Illness	2
Bizarre Behavior	2
Shouting	2
Paranoia	3
Violence Against Others	2
Above Normal Physical Strength	2
Sudden Tranquility Lethargy	2
Moderate Physical Activity	2
Intense Physical Activity	3
Obesity	1
"Big Belly"	2
Profuse Sweating	4
Shivering	4
Ineffectiveness of OC Spray	2
Cyanosis of Lips/Nail beds	5
Confusion/Disorientation	3

Score 16 or above: Subject is at **EXTREME RISK** for sudden in-custody death syndrome (SICDS). Immediate medical attention is necessary.

Score 10–16: Subject is at **HIGH RISK** for SICDS. Immediate evaluation by EMS personnel is necessary. Medical treatment may be warranted. Subject must be monitored closely.

Score 5–10: Subject is at **MODERATE RISK** another officer familiar with the Risk Assessment Scale and SICDS. Subject should be monitored by police and Detention Staff.

Score 0–5: Subject is at **LOW RISK** for SICDS, based on known risk factors. Personnel should be watchful for any signs of distress that would preclude the assessment scale.

IMPORTANT: THE FOLLOWING CONDITIONS NECESSITATE IMMEDIATE MEDICAL ATTENTION:

- Profuse sweating and shivering
- Loss of consciousness
- Seizure
- Respiratory rate below 6 per minute
- Severe headache
- Chest pain
- Obvious respiratory distress
- Gagging, coughing, or choking lasting more than 4 minutes after OC spray

Figure 5. In-custody death: Risk assessment scale.

information, the use of hog-tying restraint and neck holds have been reintroduced as a way of restraint in Reno, Nev. The restraint process is recognized as being necessary at times. The take home message is: "Knowledge is safety." The subject is placed in a lateral position with a police officer in attendance at all times (Fig 6). The subject is considered one-on-one with the police, is a critical patient, and is cared for as a one-to-one nurse to patient ratio. The patient remains restrained and with an officer until the desired response is obtained. The police are also cognitive of the signs of impending collapse and release the subject ac-

cordingly. If the patient makes the statement "I can't breathe" or "I am going to die," he is reevaluated and released immediately.

The sudden death after an episode of excited delirium is due to a combination of physiological events. The event is precipitated by psychotic breakdown or as a result of drug use. There is an increase in oxygen demand secondary to the profound increase in activity. There is increased epinephrine and norepinephrine release into the system. The cardiac oxygen demands become intense, without an opportunity to rest and resupply. The heart rate and respiratory rate increase. With

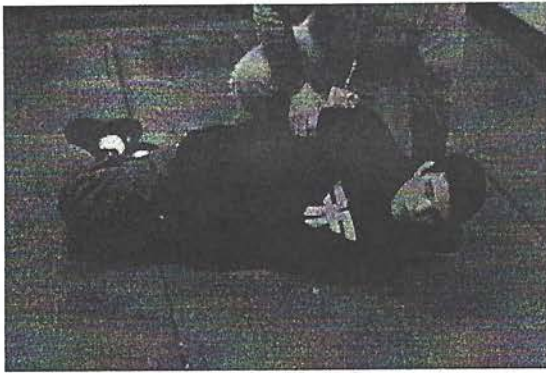


Figure 6. Subject is placed in left lateral position, with hog-tie restraints. Respiratory status is evaluated routinely.

a prone restraint, the diaphragm is inhibited and is unable to expand and allow for oxygenation. Panic and increased oxygen demand occurs and, after a relatively short amount of time, there is cardiac and respiratory collapse. Autopsy reports are nonspecific for injury.

Positional asphyxiation is determined after obtaining a history surrounding the cause of death. The cause of death for these individuals is similar to the positional asphyxia that occurs when an alcoholic becomes stuporous and falls into a position that creates respiratory compromise. This can also occur with epileptic patients who are unable to control their airways. Medical examiners argue that people who die of excited delirium death syn-

drome while restrained are not victims of incompetence or brutality, but rather victims of their own long-term drug use, which resulted in a strained heart that further exacerbated the victim's condition.¹⁷

This article focused on the definition of SICDS, its clinical manifestations, contributing factors leading to a diagnosis of SICDS, and interventions to be employed when an individual is in custody. Overall, multiple factors have been associated with sudden death when a person is restrained and is in an excited delirium state. These individuals are at a high risk for sudden death. Law enforcement officers and hospital personnel should be aware of the risks associated with restraints in subjects/patients in an excited delirium state. Careful screening and monitoring of these people and use of appropriate communication techniques need to be immediately initiated. If upper-body holds or prone position restraining are warranted and used by those specifically trained in these techniques, diligent monitoring and observation of these subjects must be done. Immediate medical attention and examination needs to take place if the person meets assessment criteria for his condition to exacerbate to a worsening and potentially deadly state. By implementing procedural protocols, the potential for SICDS may decrease.

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